THE UNIVERSITY
OF ILLINOIS
LIBRARY
625.05
RAL
v.11

REMOTE STORAGE

108
109
151

623.05
RAL
V. 11

REMOTE STORAGE

LIBRARY UNIVERSITY OF ILLINOIS
23454 / 169

Railway Electrical Engineer

623.05
RAL

Volume 11 January, 1920 Number 1

OUR DELAY IN PUBLICATION

The time between the publication of the November issue of the *Railway Electrical Engineer* and the day when you were startled by having the December number placed in your hands, was too long a period to pass by without a few words of explanation. It is generally known that a great many periodicals were obliged to suspend publication last fall owing to a lack of harmony between the printers of New York City and their employers. It was during this period that the *Railway Electrical Engineer* quietly "went west"—not all the way, as you may have thought, but only as far as Cleveland. The October and November issues were printed there and then the guiding hands were called back to New York leaving the paper at the mercy of the printer in that distant western city. We hoped for the best regarding the December issue, but delay followed delay—Christmas came and went—New Year's Day slipped into history—it seemed as though the period of watchful waiting would never end. But one day the news came that the December number had been put into the mails.

The *Railway Electrical Engineer* has returned to New York. The present issue was put together on the old stamping ground and while the paper has not entirely recovered from its western trip there is reason to believe that conditions will once more be normal by the time the February number appears.

REVIEW OF THE RAILWAY ELECTRICAL FIELD

The increased use of electricity in railroad work is most conspicuous as we stand upon the threshold of a new year looking over the field of railway activities. It is not that so many new applications have been made, but rather that the previously existing ones have been greatly extended. For instance, the use of the electric headlight dates back many years, but the law which makes this equipment compulsory on locomotives before July 1 of this year has resulted in feverish activity in this particular department. In spite of the energetic attempts to comply with the statute it is quite unlikely that every road will succeed in having all of its locomotives equipped with electric headlights by the first of next July. Incidentally, the installation of this apparatus on many thousands of locomotives will be the means of adding materially to the ever-increasing number of electrical workers on steam railroads.

It has been estimated that during the next three years 24,500 passenger cars will be required to meet the transportation demands of the traveling public. Many of these cars will be equipped with axle lighting apparatus and it is very probable that the lighting in the new cars will be notably superior to that of similar coaches at present. The reason for this is that the public is demanding more illumination. This statement should not be construed in any way as meaning that the present car illumination is particularly bad, for such is not the case. It simply means that since the advent of the tungsten lamps people have become accustomed to more efficient lighting units and naturally expect to find the same brilliancy of illumination in passenger cars as they find in any modern hotel lobby. Just how far it will be necessary to go to meet the demands is a matter of conjecture, but it is quite possible that some form of gas-filled lamp will satisfactorily solve the problem.

The problem of lighting in general is undergoing a change. It is no longer a question of whether a building shall be lighted by electricity or by some other illuminant for, wherever it is practical, electricity has driven all its competitors from the field. The illumination problems of shops, stations and terminals have been very generally solved by the application of scientific principles in the adaptation of these units when once they have been selected. In practically every instance where a careful study of a particular lighting problem has been made the result has been remarkably successful in that much better illumination has been secured with the same, and, in some cases, with a reduced expenditure of power. These results have been made possible with the highly efficient tungsten incandescent lamp which has all but supplemented the old carbon arc lamp. In fact, the modern nitrogen-filled tungsten, incandescent lamp is such an efficient lighting unit that any marked improvement of it may be regarded only as a remote possibility.

The field of electric arc welding has been so greatly extended during the past three years that there are comparatively few parts that cannot be successfully repaired or reclaimed by this process. A clear conception of the variety of work that can be performed by the arc welding process may be had from an examination of the list of welded parts given on page 25 of this issue. While it is true that there are certain kinds of work that cannot be safely entrusted to arc welding it is equally true that work of this nature comprises a very small percentage of repair jobs and for the vast quantity of miscellaneous parts which are daily being repaired, the electric welding process stands as a model of efficiency.

Heavy electric traction in this country does not show any gain in mileage with the single exception of the

526311

Chicago, Milwaukee & St. Paul which completed another section of its general electrification plan. Twenty electric locomotives, however, have been added in electrified territories, fifteen of them going to the St. Paul and five to the New York, New Haven & Hartford.

Labor saving contrivances are becoming much more common. The time when many men were required to unload a single car has passed, for one man can now do more than a gang formerly could, by simply providing him with a suitable tractor and a string of trailers. Material handling machinery is decidedly on the increase and while specific figures concerning this type of equipment are unavailable there are many indications which show that this angle of the transportation business is receiving its full share of attention.

RAILROAD WIRELESS

In view of the remarkable improvements in radio apparatus that have been brought about within the past two years it is not surprising that the Delaware, Lackawanna & Western should renew the experiments with wireless communication which had proved so satisfactory prior to their discontinuance in 1917. The ban placed upon the operation of all privately owned wireless outfits during the war effectually prevented, until recently, any further activities along this line. In the meantime, however, the extensive use of radio apparatus in certain branches of the army had developed some exceedingly important improvements, particularly in the use of the wireless telephone. It is with this apparatus that the Lackawanna is experimenting at present, having already successfully used the telephone between a fixed station and a moving train 50 miles distant.

Although it is too early to make positive statements regarding the probable extent of wireless communication between moving trains and fixed points it is quite certain that conditions do exist where such communication would be of great advantage. This will be especially true if subsequent improvements succeed in developing the wireless telephone to a point where it can be depended upon to provide voice transmission under all conditions that may be imposed upon it. There are roads traversing sparsely settled sections west of the Mississippi river where communication between despatcher and train crews is only possible at telegraph stations many miles apart. For the despatcher to be in touch with all trains at all times is almost too much to credit and yet in the light of what has already been achieved in wireless communication, there is every reason to believe that the day is not far distant when this may be an accomplished fact.

A NEW ELECTRIFICATION PLAN

The necessity for electrifying steam railroads is much more urgent in some foreign countries than it is in the United States. A realization of this fact by those in charge of the operation of these roads has been the means of stimulating much investigation and research among the various electrified systems in the different parts of the world. It is not surprising therefore, that with so much thought given to the matter, something quite out of the ordinary should be developed. Alfred Raworth, electrical engineer of the South Eastern & Chatham, England, who has spent a considerable amount of time in this country inspecting and investigating the electrified sections of our railroads, has devised a plan for the transmission of direct current for heavy electric traction which is quite different from anything that has ever before been attempted. His plan, which is given in detail in this issue of the *Railway Electrical Engineer,* consists of the adaptation of the three-wire system of electrical distribution which has been used for lighting ever since electric power was commercially practical. The application of this principle to the distribution of power for electric traction, however, is decidedly an innovation. The scheme provides for two conductor rails and duplicate sets of equipment on locomotive or car. There are added complications, but they are offset by distinct advantages. Direct current power at 3,000 volts supplied from conductor rails can be used for multiple unit cars with this system and the voltage drop through the ground or grounded rail from train to sub-station is practically eliminated.

English railways, because of different conditions, are much harder pressed by the need of electrification than are the railroads of the United States. The indications are, however, that there will be a much more extended application of electrification in this country and it will be to our advantage to profit by the experience and the suggestions of railway men abroad.

THE RAILROAD SITUATION

Representatives from the Senate and House at Washington are doing their best in conference to reconcile the provisions of the Cummins bill, passed by the Senate, and the Esch bill, passed by the House, in order to develop a bill which will be approved by Congress and the President. The vital thing is that immediate action be taken to restore confidence on the part of the investor in railroad securities. Because of inadequate equipment and facilities the railroads are today the limiting factor in production in this country. The cost of living will go upward, rather than downward, if production is not increased unless the American public enters upon a great campaign of thrift.

Except for a few months last Spring the railroads have been unable to handle all the traffic which was offered to them at any time during the last three years. With a greatly increased traffic—which shows no sign of decreasing—the railroads are struggling along as best they can with really less in the way of equipment, when depreciation is considered, than they had three years ago. Fortunately Congressmen generally seem to recognize this and it is sincerely to be hoped that they will back this belief up, regardless of politics or party, by taking such action promptly as will enable the roads to borrow the necessary money to buy the new equipment and secure the facilities which will be necessary to give the public the service which it requires. The *Railway Age,* in its issue of January 2, estimates that the railroads will have to expend six billion dollars within the next three years for new equipment and facilities which will be chargeable to capital account; this expenditure, vast as it may seem, will only return the roads to the normal condition of pre-war years, allowing, of course, for the increased growth in traffic since that time and during the next three years. The necessity for immediate and adequate action by Congress is therefore readily apparent.

LIBRARY
UNIVERSITY OF ILLINOIS
URBANA

A Theory of Metallic Arc Welding*

An Attempt to Determine the Nature of the Transmission of the Metal From Electrode to Plate

By Ralph G. Hudson

IN the summer of 1918 the Welding Committee of the Emergency Fleet Corporation initiated an investigation of metallic arc welding in which special attention was to be given to the determination of the cause and nature of the transmission of metal from an electrode to a plate. Although metallic arc welding had been employed successfully for a considerable period it was appreciated that its application was based upon empirical methods, and to make greater use of such welding in shipbuilding it was evident that its basic principle should be investigated as thoroughly as possible so that inferior methods of metallic arc welding might be eliminated.

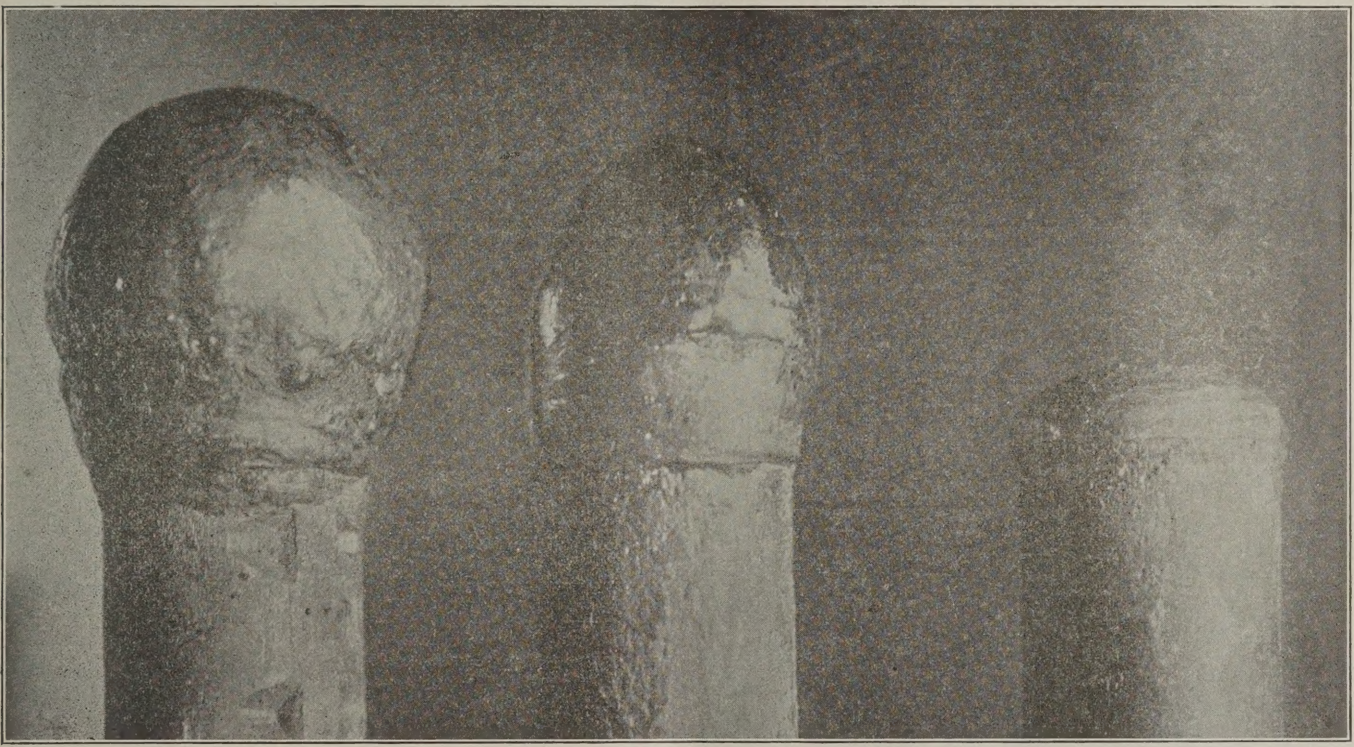


Fig. 1.—Effect of length of arc upon the size of the electrode globule. At the right, a globule developed with a very short arc; in the middle, with a moderate length of arc; at the left, with a very long arc. These are 3/16" electrodes magnified 6.8 diameters. The current strength in each case was 100 amperes. Each globule contains a cavity; in the smaller globules, the cavities are usually open, and resemble small drill holes, while in the larger ones they are usually closed and are surrounded by a thin skin of metal.

The object of this paper is to present the results of an investigation of this character conducted in the laboratories of the Massachusetts Institute of Technology.

It should be noted that at the beginning of this investigation no satisfactory explanation had been given for the transmission of metal from electrode to plate. In downward welding the deposition of metal might be attributed to gravitational force but in upward welding no such explanation could be offered. The fact that an electric current is employed in the process suggested the possible existence of forces of electrical origin which might pull metal from the electrode to the plate. Calculations of the magnitude of the electrical forces that may exist during metallic arc welding indicate that they are negligible and may therefore be eliminated as possible causes of action. This view is further substantiated by the fact that satisfactory welding may be performed with current flowing in either direction or with alternating current and that such differences as may exist with different directions of the current may be explained by consideration of the relative heating properties of such currents at the terminals of an electric arc.

In conducting this investigation the writer, following the suggestion of the committee, first attempted to obtain a photographic record of successive phases of the welding arc by means of a high-speed motion picture camera. The camera was specially constructed and when set up was found to operate satisfactorily at a rate of thirty-two pictures per second; the ordinary camera operates at sixteen pictures per second. One thousand feet of film were exposed with this camera, the character of the arc being varied by changing the direction of the current, length of arc, type of electrodes, etc. In photographing an electric arc of any kind the luminosity of the arc itself is so great that the other parts of the apparatus —electrode, plate, molten drops, etc.—do not appear on the film except as they may appear in silhouette against the arc. The films thus exposed therefore show only various shapes of the arc itself and an occasional view in silhouette of the electrode and plate. Since motion picture negatives are necessarily small in area, a full size reproduction here would be of little interest and it was found that magnification of the film pictures only disclosed their silver grain structure without adding to the detail.

---

*Abstracted from the Journal of the American Welding Society.

The principal use made of these films by the writer was to examine them one by one with a low-power microscope with transmitted light. A systematic examination of sixteen thousand pictures in this manner disclosed certain important features mentioned later. Although the photographic difficulties were evident, the writer decided to take further magnified pictures of the arc with a short exposure focal plane shutter. A camera was set up which would magnify the arc about eight diameters. Instantaneous photographs of the welding arc obtained with this camera suffered from the same domination of the plate by the arc of the exclusion of all other phenomena.

While focusing this camera it was realized, however, that more could be seen with the eye on the ground glass than could be obtained photographically or by direct observation through dense glasses, and the writer therefore began an extended study of metallic arc phenomena as seen in magnified form on the ground glass. With this device the action of the arc could be examined without screening the eyes and with the further advantages offered by magnification and observation of the action in its true color.

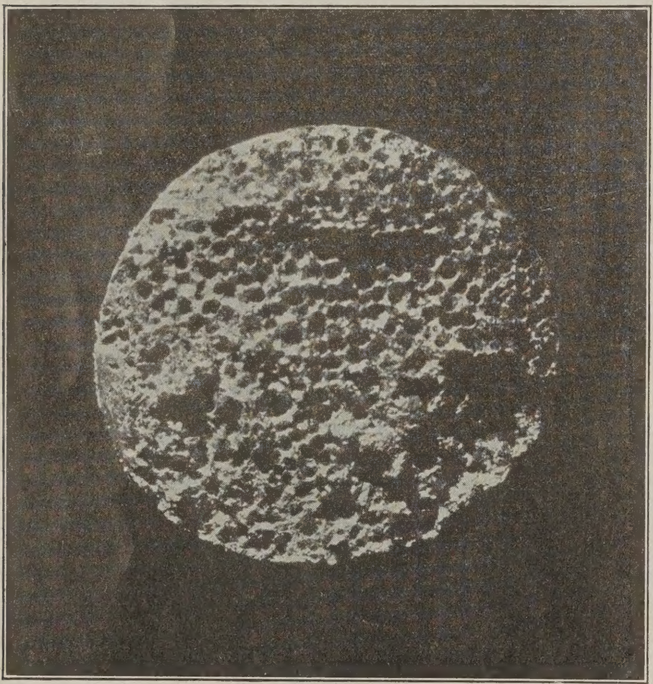


Fig. 2.—The surface of an electrode on the interior electrode end of a large globule. The pitted surface suggests irregular fusion of the electrode due to different temperatures of fusion vaporization and chemical combination of the ingredients under the influence of rapid changes in temperature. Particles may be seen under magnification to emerge from these cavities during welding. The magnification is 9.6 diameters.

When an arc is struck between a steel electrode and a steel plate the end of the electrode and a spot on the plate are heated to a high temperature and metal is transferred from the electrode to the plate. The electrode is heated to a higher temperature than the plate because the heating action of the arc is more concentrated in the case of the electrode and because the heat conduction away from the hot spot is greater in the case of the plate. An analysis of steel electrodes usually reveals the presence of at least ten elements: iron, carbon, manganese, copper, sulphur, phosphorus, silicon, oxygen, nitrogen, and hydrogen. Since the melting points and other thermal constants of these elements and their compounds vary widely and their chemical affinities are quite different, it is to be expected that the constituents of an electrode subjected to a high temperature will change from solid to liquid or gaseous form successively and not at the same instant. Since the melting point of iron is higher than that of any other constituent of an electrode with the exception of carbon, which combines rapidly with oxygen at welding temperatures to form carbon monoxide, it is furthermore to be expected that in the welding process the iron constituent of the electrode will melt last.

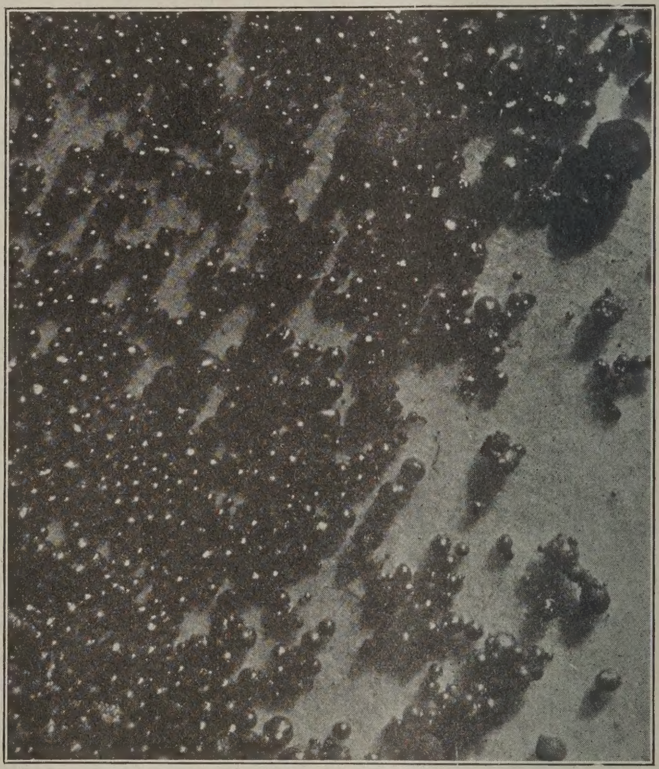


Fig. 3.—A photograph of the dust which accumulates around the work during metallic arc welding. The magnification is 20.7 diameters. This dust consists of projected particles which solidify without fusion with the plate and in many cases become connected to other particles forming chains. It will be observed that in general the projected particles are almost perfect spheres. They may be crushed easily as the interior is usually hollow.

The thermal changes just described are known to take place during the application of heat to any complex substance. In metallic arc welding the temperature changes which take place differ, however, to a marked degree from the changes incident to the usual methods of heating metals in that a small mass of the electrode in welding is subjected to a high temperature for a very short interval of time. The distinctive thermal feature of metallic arc welding is then the sudden rise and fall of temperature in the metal transmitted to the plate. Under the circumstances it may be seen that the melting of the iron is delayed by the heat absorbed by the other constituents of the electrode and that this fact together with the limited time of application of high temperature disproves the possibility that the iron is completely vaporized in the welding process. When a projectile is fired from a large gun, for example, the initial temperature of the gas behind the projectile is believed to range between 3000 and 4000 degrees C. Although this temperature greatly exceeds the melting point of the material of the projectile, there is little evidence of melting on the surface of the projectile because the projectile is not heated by the adjacent gas for a period long enough to melt its surface.

An increase of temperature in most materials is accompanied by a marked increase in volume and in chemical changes resulting in the formation of gases the reaction is usually accompanied by an immense change in volume. While various changes in volume may take place among the constituents of the electrode during metallic arc welding, the greatest possibility for such expension may be found in the formation of carbon monoxide. It is therefore to be expected that a globule will be formed by such expansion on the end of the electrode during welding. Typical electrode globules developed in this manner by various lengths of arc during the welding process are shown in Figure 1. Each globule contains a cavity which may be seen clearly during welding on the ground glass of the camera described above and is also present in the cold contracted globules shown in the figure. In the smaller globules the cavities are usually open and resemble small drill holes, while in the larger globules the cavities are usually closed and are surrounded by a thin skin of metal.

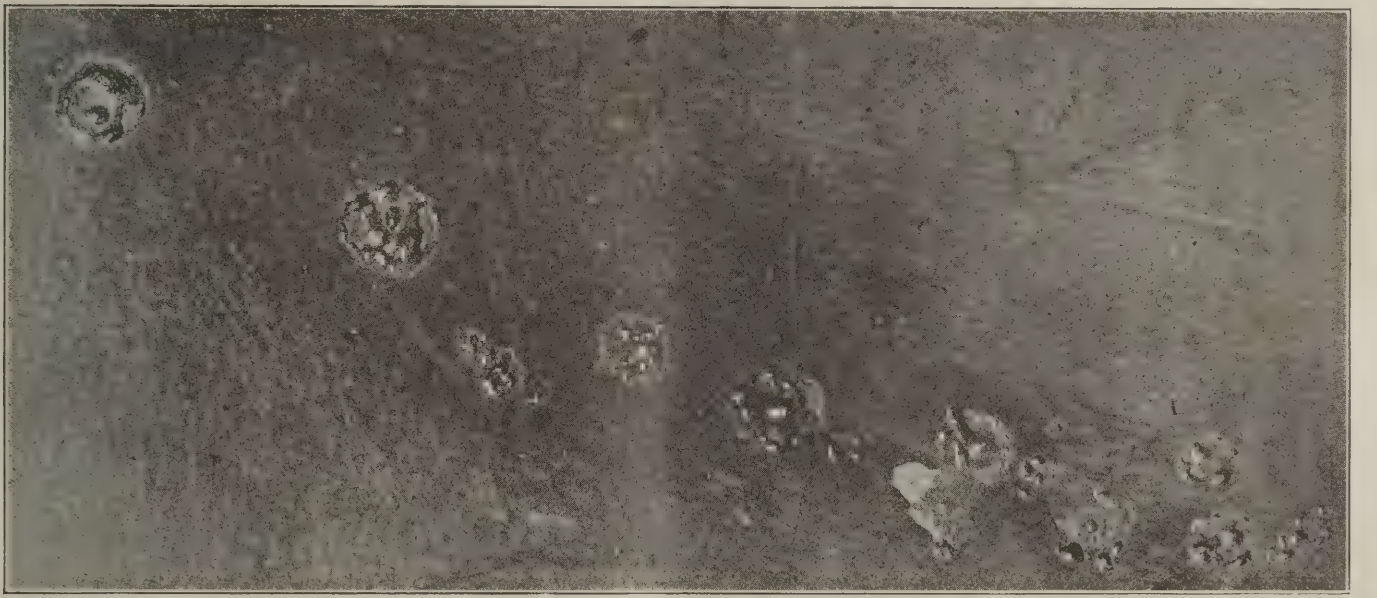


Fig. 4.—Metal projected from a hot electrode globule to a cold electrically insulated plate when an incandescent electrode is moved at a speed of four feet per second over the surface of the plate. The photograph shows only a small portion of the projected metal, the remainder being scattered beyond the region photographed, or having become detached from the plate together with some of the flaky oxidized surface. The magnification is 8.2 diameters.

An electrode globule maintained in continuous contact with the plate to prevent the formation of the glaring arc and heated by a heavy current may be seen under magnification on the ground glass to expand and blow out minute particles at high velocity from the thinnest side walls, a contraction of the globule occurring after each explusion of particles. The particles appear to originate in the inner electrode surface of the globule. If the globule is suddenly detached and the arc interrupted at the same instant in ordinary long arc welding, the inner electrode surface of the globule presents the appearance shown in Figure 2. The pitted electrode surface suggests irregular fusion due to different temperatures of fusion, vaporization and chemical combination of the ingredients under the influence of rapid changes in temperature.

Owing to the complex structure of the electrode, it is not easy to determine the exact nature of the vapor content of the globule. That the vapor consists partly at least of carbon monoxide gas is suggested by the fact that such globules do not form in general when the end of the electrode is heated in a reducing (deoxidizing) atmosphere. It is also found impossible to weld with an electrode containing practically no carbon in a reducing atmosphere. In welding under water it was observed that bubbles of gas rise continuously to the surface of the water and burn, indicating the possible dissociation of the water with the absorption of oxygen by the electrode and the rejection of hydrogen to the surface of the water. After a globule had been maintained for several minutes at high temperature in contact with a plate in air, it was observed that all expulsion of particles ceased. It may be inferred from this that all of the vapor forming constituents of the globule had been burnt out.

An examination of the motion picture films which show successive views of the arc, each with 0.0005 second exposure, reveal occasional protuberances on the electrode globule within the crater region and the paths of projected particles may also be seen silhouetted against the arc itself. That these phenomena are only found at intervals in examining the film is undoubtedly due to the fact that such particles in the arc stream are rendered invisible by the luminosity of the arc and that such protuberances and projectile paths are only visible when they happen to screen the arc. The expelled particles found about the work when welding—the familiar bluish-grey dust of the welding room—or when collected under water are found to be spherical shells indicating that a portion of the vapor within the glouble is carried away with the projected particles. A photograph of these projected particles, magnified 20.7 diameters, is shown in Figure 3.

If the electrode while welding is suddenly swept across and adjacent flat insulated surface, small spots of metal are found on the surface at regular intervals over the surface traversed by the hot electrode. A photograph of a small portion of such a path is shown in Figure 4 and a more highly magnified view of one of the spots in Figure 5. The regularity of spacing of these spots when the differences are not magnified is quite striking. The same effect was observed by holding an incandescent electrode—just removed from ordinary welding—over the rim of a revolving iron wheel. It was determined in this way that the average frequency of projection was 50 per second. The duration of such projection was approximately one-fifth of a second; the projection terminating with the cooling of the electrode.

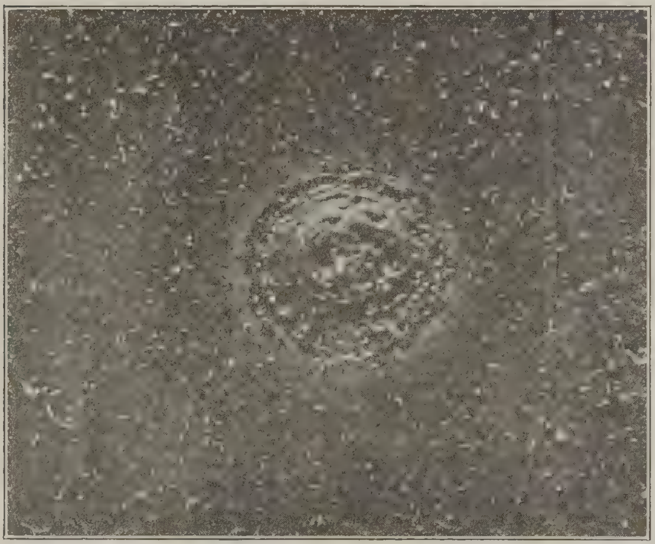


Fig. 5.—A higher magnification, 16.7 diameters, of a nucleus of metal projected on a cold plate from an incandescent electrode globule. Metal is thus projected by heat effect alone at regular intervals with an average frequency of 50 projections per second. The actual diameter of such projected spots ranges from 0.01 to 0.05 inch.

It would appear from the observed facts that the metal desposited during metallic arc welding is transmitted in part at least in the form of minute particles which are projected from the electrode globule by the internal expansion of some vapor, possibly carbon monoxide. The expelled particles pass through the arc too rapidly to become vaporized and reach the plate in a fluid state. If the expelled particles strike solid metal they either ricochet along the surface—which explains the accumulation of iron dust in the welding room—or flatten out without fusion, the most common cause of poor welds. If the particles strike a fluid metal they penetrate the fluid and solidify with the molten surface of the plate.

It is a well-established fact that the best welding is obtained with the shortest arc and the worst welding with the longest arc. It will be noted in Figure 1 that the size of the electrode globule also increases with the length of arc, the best welding being obtained with the smallest globule. A small globule implies greater concentration of projected particles in the direction of the opposed fluid spot. In downward welding a large globule becomes elongated by gravity, the lower part of the hollow globule becomes thickened by downward flowing metal, the side walls become stretched and thinned, and particles are projected wastefully through the side walls at right angles to the arc. The globule as a whole frequently breaks away from the electrode and drops without fusion on the plate. Electrode ends rejected by a welder and presenting the appearance shown in Figure 2, or the large globule in Figure 1, constitute substantial evidence of ineffective long-arc welding. In upward welding a large globule tends to fall to one side or the other by gravity and prevents the efficient projection of metal.

Any material which serves to increase the melting point of the surface of an electrode must, in accordance with the stated theory, improve the conditions under which particles are projected from the electrode globule. The cup shaped surface formed at the end of such an electrode will reduce the amount of indirect projection of particles to a minimum and the increased stability of the arc will reduce the difficulty of manipulation of the electrode, since the length of arc may be varied over a greater range without interruption. It would appear that most of the coatings suggested for electrodes perform the function of cooling the surface of the electrode by vaporization and in some instances, owing to the rapidity of the action, remain in a fluid condition about the sides of the electrode globule. It should also be noted that since iron oxide (rust) has a higher melting point than steel, that rust should not be removed from electrodes and that rusty electrodes will usually work better than bright clean ones. In many cases the outside layer of bare electrodes may be changed by drawing and heat treatment so that it has a higher melting point than the interior. The ideal electrode would have a high melting point shell—tunsten for example—surrounding a lower melting point interior containing sufficient vapor constituents to eject metal constantly when heated by the electric arc.

The writer would suggest certain promising subjects for further study. First, a determination of the character of the vapor found in an electrode globule. Second, a determination of the best surface material for electrodes; first cost and effect on the finished weld to be considered. Third, the effect of welding in a reducing flame upon the character of the weld. The writer has found that such a weld is more ductile and reveals less formation of nitride. Fourth, an investigation of the value of welding under water as in the case of ships, tanks, etc. Fifth, the use of materials other than steel in metallic arc welding. It will be noted, for example, that the zinc constituent of brass under the influence of a rapid increase in temperature may melt and vaporize before the copper constituent begins to melt. If the theory which has been so carefully outlined above is correct, it would appear quite probable that satisfactory welding could be done with brass electrodes, a thing which would undoubtedly find an application.

Alternating Current Theory and Practice

A Brief Practical Review of Basic Principles Prepared for Railroad Electrical Workers

By O. C. Callow

1. ALTERNATING CURRENT

ELECTRIC current flows in a conducting circuit as a result of an electrical pressure or voltage, between different points in the circuit. The flow of current is similar to the flow of water in a pipe circuit due to head. If the circuit is complete, a current will always flow from a point of higher voltage to a point of lower voltage.

Electric voltage may be set up in various ways. The simplest medium is the galvanic battery which, due to chemical reactions, produces a voltage difference between its positive and negative terminals. The positive terminal has the higher potential or electric head, so to speak, so that current in a circuit connecting positive and negative terminals will always flow in one direction, namely, from positive to negative terminal. Fig. 1 shows this condition.

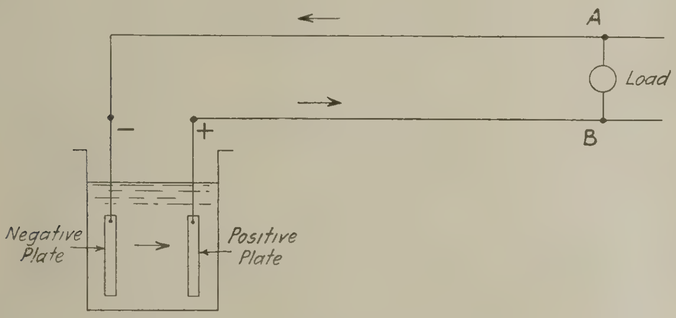


Fig. 1. Simple Galvanic Battery and Circuit Showing Direction of Current Flow

If a two pole double throw switch were inserted in this circuit, as shown in Fig. 2, and, if this switch were thrown back and forth repeatedly from one position to the other, line *A* would be connected to the positive battery terminal for the top position of the switch and line *B* would be connected to the positive terminal for the bottom position of the switch. The current would flow from *A* to *B* during the interval the switch was in the top position and from *B* to *A* during the interval the switch was in the bottom position. In other words, due to alternation of the point of higher voltage, the direction of flow of current would regularly reverse. The current might, therefore, be called an alternating current. An alternating current is an electric current which reverses its direction of flow at rapid, regular intervals.

The action of the current resulting from the arrangement described in the previous paragraph might be illustrated as in Fig. 3. This shows that during the interval of time, $t\ t_1$, while the switch is in one position, a positive current flows as represented by a vertical distance above the zero line. When the switch is thrown to the other position, during the interval $t_1\ t_2$, a reverse or negative current flows, represented by a vertical distance below the zero line. The figure shows a number of these alternations and gives a conception of the action of alternating current.

If all electric current were produced by batteries the field of electricity would be very limited. Alternating current would be particularly obscure for battery current is normally continuous or uni-directional and, as has been shown, a reversing medium is necessary to secure alternating current. The bulk of our electric power, however, is produced by revolving generators. These, as will be shown, are well adapted to the production of alternating current.

The electric generator depends, for its action, upon relations existing between electricity and magnetism. Referring to Fig. 1, if a compass were held near the wire carrying direct current from terminal *A* to terminal *B*, it would be found that the compass would be deflected, indicating the presence of a magnetic field. If this compass were held near the wire carrying alternating current in Fig. 2, a magnetic field would again be found, but the needle would reverse every time the current reversed, showing that the direction of the magnetic field depends upon the direction of flow of current in the wire. It is a fundamental condition that a wire or conductor, carrying electric current, is surrounded by a magnetic field, the direction of the magnetic field depending upon the direction of flow of electric current in the conductor.

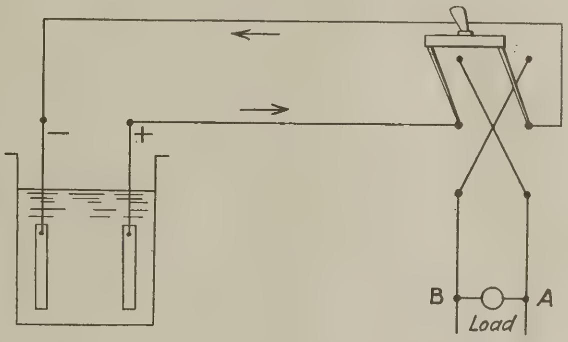


Fig. 2. Simple Device for Producing Alternating Current From Direct Current

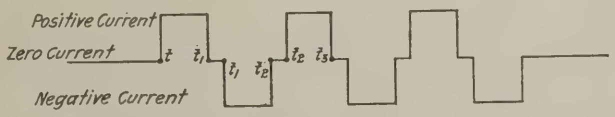


Fig. 3. Diagram Illustrating the Reversal of Current During Successive Intervals

It was discovered by Faraday, many years ago, that, if a conductor is placed in a magnetic field and is held stationary, no action occurs, but, if the conductor is moved across the magnetism a distinct field is set up, encircling the conductor. Faraday also discovered that a wire or conductor moved across a magnetic field became surrounded by its own field and that, as a result, an electric voltage was introduced or generated in the wire or conductor. This condition must be accepted as a discovery without full explanation. It is the fundamental principle upon which all electric generators are based.

We are all familiar with the horseshoe magnet, having a north and south pole. Let us consider a number of these magnets set up in a row, as shown in Fig. 4. If we move a conductor *C* along a line past these magnets the conductor will pass, first, under a north pole, then under a south pole and continue thus to the end of the row. As the conductor passes under the north pole a magnetic field is set up around it in a given direction and a voltage difference is generated between the ends of the conductor. When the conductor passes under the south pole a magnetic field is set up around it in the reverse direction and the voltage in the conductor reverses, the point of higher voltage being transferred to the other end of the conductor. The action of this voltage is shown in Fig. 4, which is similar in principle to Fig. 3. It will be seen that, if a conductor be moved past alternate north and south poles, an alternating voltage is set up in the conductor. If the ends of the conductor be connected together to form a closed circuit, an alternating current will flow due to the alternating voltage or pressure.

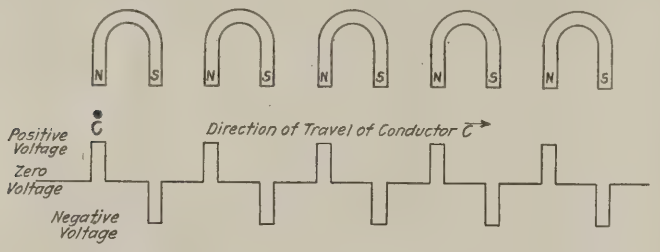


Fig. 4. Diagram Showing the Positive and Negative Impulses Induced in a Conductor as it Passes by Alternately Placed North and South Magnetic Poles

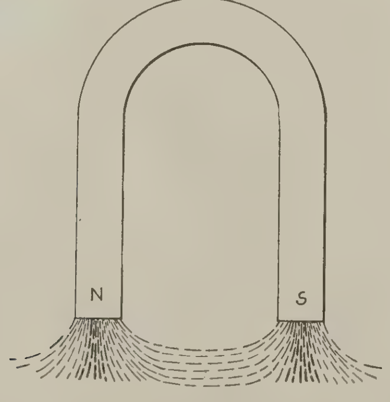


Fig. 5. Sketch of Horse-shoe Magnet Showing the Maximum Number of Lines of Force Located at the Center of the Poles

If a study be made of the magnetic field produced by the north and south poles of any of the horseshoe magnets shown in Fig. 4, it will be found that the so-called magnetic lines of force will flow out of the north pole into the south pole, as shown in Fig. 5. These lines will be found to be of greatest density at the center of each pole face. One of the fundamentals governing the generation of voltage by moving a conductor across a magnetic field is based upon the fact that the value of the generated voltage will depend upon the number of magnetic lines of force cut by the conductor and the speed at which they are cut. Again referring to Fig. 4 we find the voltage represented by a horizontal line, while the conductor is passing the face of each north and south pole and that the voltage drops to zero as soon as the conductor has passed the pole, generating full voltage again in the reverse direction when it reaches the next pole. Now, inasmuch as it has been shown that the density of the magnetic fields is not constant and that the voltage generated will depend upon the number of lines of force cut, it can be seen that the voltage generated will not be constant while the conductor passes each pole and that it will not follow exactly the form shown in Fig. 4.

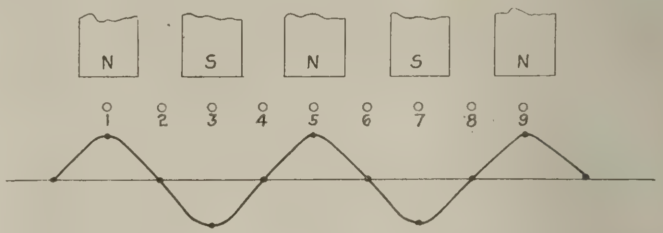


Fig. 6. Curve Showing the Rise and Fall of Positive and Negative Voltages as a Conductor Passes Through the Non-uniform Field From the Magnet Pole

Referring to Fig. 5 we find the maximum number of lines of force to be at the center of the pole face. Therefore the maximum voltage will be generated in the conductor when it is in this position. As it is moved across the pole face towards the next pole, it will cut less lines of force and the generated voltage will be lower. As the conductor approaches a point midway between the two poles it will be moving in a direction parallel to most of the lines of force and will, therefore, only cut a small number, and the voltage will gradually fall away, until the conductor is exactly half way between the two poles, at which instant no lines of force will be cut and no voltage generated.

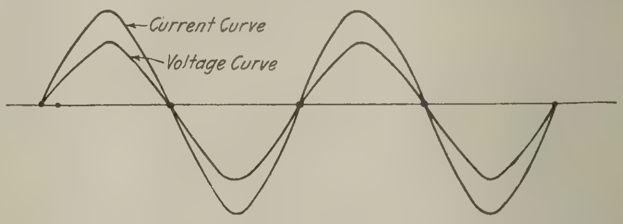


Fig. 7. Curves Showing the Relation of the Current to the Voltage in an Alternating Current Circuit

If we again consider a row of horseshoe magnets as shown in Fig. 6 we find that the conductor in position *1* will generate the maximum voltage. This voltage will fall off, as shown in the curve, as the conductor is moved towards position *2*, at which point it will have fallen to zero. Moving toward position *3* it begins to cut lines in the opposite direction the voltage builds up, until in position *3* it is again at maximum. Cutting the maximum number of lines of force in the magnetic field of the south pole, and so on, giving a curve which will vary very little in shape for the voltage generated in a conductor moving across any magnet field.

It has been shown that if the ends of the conductor are joined a current will flow through it. This current can only flow when there is a voltage generated in the conductor and must, therefore, drop to zero when the conductor is between the north and south poles. As the current will always flow from a point of higher voltage to a point of lower voltage, it must always be flowing in the direction which the voltage tends to send it. We therefore find that the value of both the voltage and current generated in the conductor follow the same curve-like form, reaching zero at the same time and maximum at the same time and in the same direction. Fig. 7 shows the voltage and current generated by the conductor passing alternate north and south poles as shown in Fig. 6.

An electric generator is essentially a device for moving electric conductors past magnetic poles for the purpose of generating electric voltage in the conductors. In order to have a magnetic field, alternate north and south poles are necessary. The conductors, therefore, move past alternate north and south poles. As a result, they have generated in them, alternating voltages. It follows that, in its simplest form, the electric generator generates alternating voltage and produces alternating current in any circuit that may be connected to its conductors.

In the case of the battery first considered, it was found necessary to introduce a reversing switch to secure alternating current from a direct current source. Similarly, to secure direct current from an electric generator some medium is required to reverse or rectify the current which, as stated above, is generated as alternating current. It is the function of the commutator of direct current generators to rectify the generated alternating voltage. In the alternator, the voltage is not rectified. The machine terminals are connected directly to the conductors and alternating voltage and current are taken directly from them. The absence of the commutator is one of the great advantages of the alternating current generator.

The Trials and Troubles of a Car Lighting Man

Hinkey Dee's Method of Acquiring Knowledge Results In a Sore Head When Put Into Practice

MY brain gets better every day, but it seems to me that the older Jimmy Goat and Eddie Ram get the dummer they get. I know a bunch of superintendents and master mechanics and electrical engineers that's as dum as a board fence but these two guys is dummer than Mike Murphy's grandmother ever was. I talk and read and try to explain all about car lightin' to these two fellers in particular, because you know I like Jimmy and Eddie and I would like to see them get along, but I'm beginning to get discouraged. Guess the only way I'll get anything into Jimmy Goat's head will be to use a steam hammer like they use in a blacksmith shop. Eddie Ram seems to get it into his head for a couple of days then he loses it. I guess I'll have to tell it to him over and over again every third day until he is able to hold on to it.

Now just to show you how dum these two fellers is I'll repeat an argument we had yesterday. I was sittin' in a car quietly and peacefully doin' me work when I kind of dozed off into a little nap. I slept a little while, about two hours, when I felt somethin' tickling me nose and as I woke up there was Jimmy Goat with a straw playin' a trick on me. He said, "Hello, Hinkey Dee, your hard at it I see." I said, "Yes, Jimmy, I worked so hard fixin' a lamp socket that I just got all exhausted and fell asleep, but I wasn't exactly asleep, Jimmy, I was just layin' with me eyes closed." Then Jimmy said, "You look tired out, Hinkey." I said, "No, I'm not so tired as I have a sore head." "What happened to your head?" said Jimmy, "Did you bump it?" "No," says I, "I didn't bump it, I just had a tilt with the boss, that guy don't know nothin' and he never can agree with me. Why that guy don't actually know a circular mill from a wood mill. Why, Jimmy, he's as dum as you and Eddie Ram. I said to him, 'Say, boss, isn't it funny how many circular mills a wire has to go through before it is wire.' Then he said, 'What's that you said, Hinkey?' I said, 'Why, ain't it funny the number of circular mills a wire has to go through before its wire.' Then that big stiff had the nerve to sit in front of that rolled top desk and laugh at me! I got mad, I said, 'Well do you think it's a good joke?' 'I sure do,' said the boss. Then he tried to tell me that circular mills was the cross-section or some kind of a cross area of a wire on the end. I don't know what he was tryin' to get out of him but I remembered one time I was passin' a power house where they have all kinds of engines and dynamos and all and I asked a man standin' in the doorway about circular mills and he told me all about it. Then to think that that poor boob don't even know that much."

Then Jimmy said, "Well, Hinkey, what do they mean when they say a wire has circular mills?" I says, "Well, here comes Eddie Ram and may be he don't know either, then I can tell you both at once and save some breath." "Say, Eddie," says Jimmy Goat, "do you know what they mean by sayin' a wire has circular mills?" "I don't believe I do," says Eddie. "Well, I just asked Hinkey Dee to explain it to me and he said maybe you'd like to know all about circular mills, too." "Yes, I would, says Eddie, "I remember hearin' two fellers talkin' about circular mills one time and I wondered just what kind of mills them is." "Now go on, Hinkey Dee," says Jimmy Goat, "tell us what them circular mills is."

"Well," says I, "circular mills ain't what youse guys think them is, no thems all together different. In the first place," says I, "a circular mill is a place where you make wire. It's easy to see after your told once, wire is round, round wire, anything round ain't square, why no, it's circular, the wire is circular, the mill is a mill, wire mill or a circular mill. Do you see it now fellers," says I. "Oh! I see it now," says Eddie, "just like a round biscuit factory, round biscuits, biscuit mill or circular mill." "Good for you, Eddie, that's right," says I. "Did you grasp it, Jimmy?" "Indeed I do certainly see that, that's plain as A B C, why just like a cannon ball company, cannon balls are round, round factory, circular balls, yes, sirree, I sure see that all right. Circular mills is round just like a race track."

"Well, now, that you both could understand and know what a circular mill is so quickly I will go on and explain more about what it is to you."

Says I, "You see they can't built a circular mill large enough to make a wire, why just think how long some wire is, they could never build a mill long enough to make a wire as large as that." "Right you be," says Jimmy Goat. "Thats right too," says Eddie Ram. Then both together they said, "well, Hinkey Dee, how do they make a wire as large as that?"

"Well," says I, "then to make a wire as long as that you have to have a lot of mills, some wire requires more mills than other wire does. It all depends on how much wire you wanted, for instance, if you wanted a wire ten miles long you'd have to have enough mills to reach ten miles in order to make the wire all in one piece.

When I felt somethin' ticklin' my nose and as I woke up there was Jimmy Goat with a straw playin' a trick on me.

"Now do you fellers understand what I'm driving at," says I. "Yes I see that all right," says Eddie Ram and Jimmy Goat, "but what do they mean when they say number 1 wire, number 4 wire, number 6 wire and so on?" Now could you imagine anybody as dum as that! I had to laugh right out to think anybody didn't know as much as that. "Oh, Jimmy, that's easy," says I. "You see they say a wire has a certain number, like 2, 4, 6, 8, they mean that the wire has that many braids or layers of insulation on it. For example, if a wire didn't have no insulation, then it would have no number, or if you wanted to know the number of any wire you'd just pick up the wire in one hand and take your penknife in the other and cut into it, each cover you'd cut you would count. If it had one cover then it would be number one wire, if it had four covers it would be number four wire and so on. It all depends on the number of covers you want." "Why," says Eddie Ram, "I always thought that was the conductivity." "Oh, how you make me laugh," says I. "Why, Eddie, you and Jimmy want to wake up and know something, why anybody knows what conductivity is. Why conductivity is a word derived from the word conductance. When you speak of wire having a certain conductance you merely state the number of small wires or strands used to make up the wire. For example, if a wire was one solid wire then its conductivity would be one, if it had 1,000 strands then its conductivity would be 1,000." "Say, Hinkey Dee," says Jimmy, "I'm much obliged to you. I'm sure I understand all you said. Yes, sir, that's plain about conductance, I'll remember that. An easy way to remember it would be to think of a trolley car, one conductor, one conductance, two conductors, two conductors. While you're at it, Hinkey Dee," says Jimmy, "what's all this talk about resistance, what's this resistance people talk about?" "My goodness, don't you know that either? Do you know what resistance is, Eddie?" "Never heard of it," says Eddie. "Resistance," says I, "anybody knows what resistance is. Resistance is the steel covering that goes around the outside of wire.

I walked up to him and demanded of him what he was doing. He got mad and hit me on the head with his club. I got kind of dizzy so Jimmy Goat and Eddie Ram carried me back to the battery house.

Haven't you seen wire with a steel or lead covering on it?" "Sure," says Jimmy. "Well that is resistance. You see some wire has resistance and some wire don't have resistance. It all depends on the kind of wire it is." "You're great," says Jimmy Goat, "but tell me, Hinkey Dee, how I could make my head as big as yours—what could I do to know as much about everything as you do?" "Well, fellers, there's a lot to learn about wire and you might just as well make up your mind this minute to get down to business and learn all about it. Just think of all the kinds of wire there is. For instance, electric light wire, trolley wire, magnet wire, underground wire, picture wire, party wire, overhead wire, telephone wire and a million other names that's all wire. So you see what you have ahead of you. It's all wire and you might just as well get down to business.

"Why, do you realize it took fourteen years of hard sound practical studyin' for me to learn all about wire? I'll admit I have a big head and a quick brain, but even at that it took me all these years to get it. A feller might know all about axle generators and regulators and batteries, but where would a car lightin' man land if he knew all about these and he didn't know all about wire.

"Remember that wires are the leads to everything in car lightin', that's why you hear me say battery leads, generator leads, lamp leads, because I know that wire leads 'em all. When you see a man doing anything electrical, just step up and ask him what he's doing. That's how I made my start, do you think I'd be a great man in electricity if I didn't ask people what they were doing. No, sir, if you fellers want to be good at car lightin' like me, you'll have to ask everybody what their doin'. Why I never think of getting on a trolley car without askin' the conductor what the electricity is that runs the cars—direct or alternating current? How many motors on the car? Does the motorman know how to run the car? How much juice does the motor take? How many lights in the car? How many passengers does the car pull? Do you have much trouble with the brakes? Does the controllers work all right? How do the controllers work? How many wires in the controller? How often do you clean the motors? How often do you wash the lamps? What makes the car run the other way? And so on. And every conductor you ask will willingly tell you all about electricity. Everytime I see a policeman calling up or ringing up I always ask him all about how the box works, how many volts, how often does he call up, does he always get who he calls up, etc.

"Now let's go out on the street and I'll show you how to learn to be good at electricity."

We walked down Main Street and there was a cop callin' up. I walked up to him and demanded of him what he was doing. He got mad and hit me on the head with his club. I got kind of dizzy so Jimmy Goat and Eddie Ram carried me back to the battery house, but I explained to them both that he was the only cop like that and that all the others were different. Eddie said, "Well, Hinkey Dee, I'd like to ask questions, but I don't like being hit over the head with a club." I explained to Eddie and Jimmy that he was the only cop that did that. "Well," says Eddie, "will you give me a list of questions to ask people." "Sure thing," says I, so I made up a list of questions as follows:

1—Who are you?
2—What are you doing?
3—What are you doing that for?
4—How do you do it?
5—How does it work?
6—Why does it work?
7—Does it work all right?
8—Explain it all to me.

Then Eddie Ram and Jimmy Goat took the list and started out to ask questions.

Moving Day for Westinghouse Men

Seventy-five engineers from the machine works of the Westinghouse Electric & Manufacturing Company of East Pittsburgh, Pa., and their families were moved on January 14 to Lester, within 10 minutes' walk of the South Philadelphia works of the Westinghouse Company, where the Machine Works Engineering Department has been transferred.

Contrary to the old system of every man's looking out for a home to which to take his family, the company has built a large number of houses which are rented to employees. Photographs were taken of the houses and sent to East Pittsburgh, along with blue-prints showing their construction and location. The engineers' families were permitted to select from the drawings and photographs, their choice of a home.

Each engineer was given a blue-print of the house in which he was to live, showing the size and number of rooms. He then made out a tag designating where each piece of furniture should be placed. The packing, crating and shipping of the furniture was accomplished without any physical exertion on the part of anyone of the families, for the Westinghouse company engaged five of the leading transfer and storage companies of Pittsburgh to go into their homes, pack, crate, and deliver the furniture to cars. The work was done in a record-breaking time. It required only eight days to complete the packing of the household effects of the 75 families.

When the furniture arrived in Philadelphia, it was unloaded and hauled in trucks to the new homes and unpacked. Carpets were laid and the goods placed in rooms, in accordance with the requests of the family. It required 40 cars to complete the shipment of furniture and automobiles. In the meantime, the employees continued their work at the East Pittsburgh plant, living with friends and in hotels.

The engineers and their families left for Philadelphia on Wednesday evening, January 14, on a special train consisting of nine Pullmans. They arrived in Philadelphia at 7:10 Thursday morning. They were given their breakfast at the Broad Street Station, Philadelphia, after which special street cars carried them to the South Philadelphia works for an inspection of the plant. They then went to their new homes.

As the Result of a Conference called by the chamber of commerce at the request of its Americanization committee, all the organizations in the city of Trenton, N. J., interested in Americanization work have joined forces and will get behind a general and comprehensive Americanization program to be formulated by Dr. Z. E. Scott, supervising principal of the public schools, and to be carried out in co-operation with the schools. It is believed that this will result in increased and much more effective work for new Americans this year.

Maintaining and Operating Electric Headlights

Systematic Inspection, Focusing, Tests on Governors and Locating Troubles are Important Items

BECAUSE of the requirements and extended use of electric headlight equipment on locomotives and because of the importance that the operation of such equipment should be as nearly perfect as possible, the Chicago, Rock Island & Pacific considered it essential to have an instruction book prepared to cover all phases of the subject that have a tendency to give trouble in the operation and maintenance of such equipment. In preparing such a book it was considered advisable to treat the subject in the most direct manner possible so that all those concerned in the maintenance, operation and handling of the equipment would have the proper instructions which form the basis of a good working knowledge of the subject.

As reference reading and to keep informed as to new improvements and detailed changes of various headlight sets, those interested are referred to manufacturer's instruction books covering their equipment.

As a further reason for the preparation of such an instruction book, it was considered necessary that the operation and maintenance of electric headlight equipment be thoroughly understood because in case of failure serious accidents might result, so that it is of vital importance that rules and instructions be prepared for the use of maintainers and others, that they may be competent and conscientious in the discharge of their duties in connection with headlight maintenance.

Tools Required By Maintainers

In order that the maintainer can do ordinary work the following tools are required:

One 1 1/16 in. straight chucking reamer.
One 9/16 in. straight chucking reamer.
One revolution counter.
One 0-50 scale voltmeter.
One 10,000 ohm magneto.
Two screw drivers, one large, one small.
One 6 in. or 8 in. side cutting plier.
One pocket knife.
One 2 lb. ball pein hammer.
One 10 in. pipe wrench.
One 10 in. monkey wrench.
One set of suitable socket wrenches.
One box wrench for turbine wheel nut.
One 6 in. or 8 in. combination plier.
One bearing puller.
One blow torch and soldering outfit.

Various other tools will, of course, be required, depending on the exact nature of the work at hand.

A tool box, of ample size to hold the required tools and some of the small miscellaneous parts used in making repairs, should be provided, in order that the maintainer will have his tools and parts convenient at all times.

Routine of Inspection

A complete inspection of the entire equipment, including the headlight turbine, dynamo, cab lamps, all wiring, etc., should be made each trip. The best practice when it is possible to do so, is to begin the inspection at the generator by testing the entire system for grounds with standard magneto. Next, thoroughly inspect the turbo-generator. Then proceed to the cab and make inspection of the lamps, wiring, etc. The turbine should then be started by completely opening the throttle valve.

With all lights turned on, an inspection should be made to determine if all the lights burn, including the cab lights, headlight, number plate light and classification lights. In case the headlight is an arc, a thorough inspection of all parts should be made. After this has been done, return to the generator, disconnect the entire load, and make a test to determine if the governor is working freely. This concludes the inspection, which should be made before the locomotive enters the roundhouse. When this procedure is followed the maintainer will have complete knowledge of the condition of the equipment and therefore sufficient time to make repairs before the locomotive is required for service again.

Detail instructions are given in the handbook for inspection tests and repairs on the various subjects, some of the most important of which are given in part as follows:

Inspection and Maintenance of Generator

The commutator is the vital part of any generator. It will not perform its functions successfully if permitted to spark. The commutator should be examined carefully for high mica; this should be maintained about 1/64 in. below the surface of the commutator segments. A small three-cornered file can be used for dressing down the mica; the portion to be removed from the segment walls can be taken care of by using a knife, then clean the slots with a strip of sandpaper so as to remove any burrs which may have been caused by the use of the file or the knife.

If the commutator becomes burnt or out-of-round, the armature must be removed and the commutator trued up in a lathe. A sharp V-tool should be used and light high speed cuts taken in truing up. Even though one is careful when turning up commutators, burrs will be found projecting over the mica grooves when the armature is removed from the lathe. To prevent short-circuiting, all burrs between copper segments must be removed with a small, three-cornered file, after which the mica must be filed as previously outlined, and the commutator cleaned and polished with a strip of fine sandpaper (not emery paper).

The brushes should fit the commutator; that is, the contour of the wearing surface of the brush should be the same as that of the commutator. This is accomplished by using a strip of sandpaper (not emery paper) about the width of the brushes. Place the sandpaper

---

*Abstract of handbook prepared by the Chicago, Rock Island & Pacific on rules and instructions governing the operation and maintenance of electric headlight equipment. The equipment under consideration consists in general of the Pyle National inasmuch as that is the type of equipment used most extensively on the Rock Island.

strip, rough side out, between the commutator and the brush, then draw the sandpaper back and forth until the brush has the proper bearing.

An even pressure of the brush upon the commutator is maintained by the tension of the brush holder springs. When this tension has been adjusted properly, it will remain fixed unless tampered with.

The brushes must always be fitted to the commutator when a new armature is applied, or when a commutator has been turned. After the brushes have been fitted to the commutator, be sure to connect the flexible brush leads to the brush holder proper. If no screws are provided for connecting the brush leads, they may be connected under brush adjusting screw. Examine all insulating bushings and washers to see that they are in good condition and do not permit grounds to exist. See that all screws and connections are tight and that the wires are properly connected to their respective binding posts.

Test the bearings for wear and have new ones applied if necessary. When bearings are being applied, care should be taken to note the condition of the turbine shaft, as it is impossible to get the life out of the bearing if the turbine shaft is worn.

To successfully operate ball bearings they must be kept clean, properly assembled and lubricated. The assembly should permit outer race of bearing to creep in housing to allow a uniform wear. A suction fit will permit this. If the fit is too tight, the bearing will not creep and therefore will not wear uniformly. If the fit is too loose, the bearing will vibrate in housing and pound out bearing seat. Ball bearings and housings should be cleaned every 60 days by removing bearing and washing same thoroughly with kerosene. The housing should be also cleaned with kerosene and blown out with air.

If there is excessive vibration, or if a machine is pounding out bearings, it may be caused by a sprung armature shaft, armature being out of balance, or by commutator end of armature spider or washer not being faced off square, so as to permit uniform contact. When the armature spider or washer is not true, an unequal strain will be developed, causing distortion of the shaft or armature.

A close inspection will locate the cause of the trouble. More often slight vibration is caused by worn bearings, especially at the turbine end in cases where the bearing is located at the extreme end.

It is important for the inspector to see that all screws, nuts, etc., used to prevent armature from coming loose are in place and tight, as this is the primary cause of worn armature spiders.

In case it is found necessary to remove the field coils great care should be used in replacing them to see that they are connected to secure proper polarity. In order to do this it will be necessary to try the machine after engine has been steamed up. In case the equipment does not then generate it will be necessary to reverse the connections.

Field coils that are in good cndition should be very carefully handled in shipment. They should first be wrapped in heavy paper, carefully packed in excelsior in a box of proper size, in such manner that there will be absolutely no hard surface coming in contact with the windings, as this might damage the insulation of the wire or bruise it, thereby rendering the coil defective and wasting a large sum of money.

Inspection and Maintenance of Wiring

The wiring throughout the locomotive should be carefully inspected and maintained, to prevent the development of any trouble. Methods of wiring locomotives in the different classes of service are in accordance with standard plans.

It should be understood that it is absolutely against the company's rules to connect jumper wires around fuse blocks or cut out fuse plugs in any manner whatsoever, since the object of the fuses is to protect the circuits and apparatus and to indicate trouble in the cab light wiring or sockets, which would not otherwise be found and in such an event a total headlight failure might be the result.

In order to eliminate the possibility of a total headlight failure by a defective branch circuit or outlet, fuses have been provided in all branch circuits, and additional fuses for individual outlets which tend to give trouble have been provided in the rosettes.

The branch circuits are protected by 10-ampere plug fuses, the individual drops by 3-ampere fuse wire. No fuses are provided for the main headlight circuit since the possibility for damage to this electrical unit does not justify their use. On the other hand, the addition of fuses with their contacts would subject the equipment to trouble not experienced without them.

The connection between the engine and tender on switch locomotives is made by means of brass connectors, made in two parts, which engage with one another and are wrapped with friction tape. To disconnect wiring between engine and tender, remove friction tape and break the connection.

Inspection and Maintenance of Headlights

The arc lamp is to be inspected, cleaned and trimmed each trip, as follows:

Disconnect the wires from the binding posts, remove the upper carbon holder together with the carbon; pull the lamp out of the case, so that access can be had to all parts; remove the electrode holder and trim the electrode. The electrode should be tapered until the point is about 3/16 in. in diameter. Remove the scale between the electrode and electrode holder. Replace electrode, so that point is 1⅛ in. above the top of the electrode holder, after which the set screw should be adjusted to touch the bottom of the electrode, being careful to have the thumb screw tight. When old style thumb screw is found to be stripped, the hole should

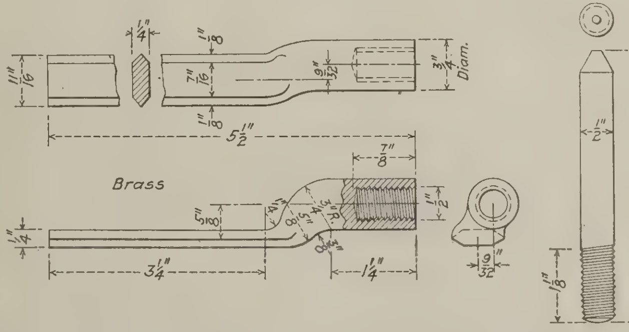


Fig. 1.—Combination Electrode Holder and Electrode

be tapped out and the new style thumb screw which is larger should be applied.

In the case of the Rock Island standard combined lower holder and electrode shown in Fig. 1, remove carbon from upper carbon holder; loosen binding post screw and adjust lower electrode holder until a 1½ in. square gage block will just fit between point of electrode and upper carbon holder foot; when this is done, tighten the binding post screw. This setting should always be maintained to fit the 1½ in. gage block.

Next, examine the upper carbon holder. This should be done very thoroughly, as much depends on the function of this part of the lamp. Examine as follows:

Note whether clutch is worn or not, and that clutch rod is of such a length as to make the position of the clutch horizontal. If it is too short it will cause the lamp to fail; if it is too long it will cause excessive current and burn up the solenoid.

One of the main causes of arc lamp trouble is a poor contact between the upper carbon holder and the contact brush. This causes the tension spring to carry the current and results in the heating and annealing it. In order to prevent the heating of this spring, it is necessary to place one fibre washer 5/32 in. in diameter and 1/16. in. thick at each end of the spring. This will insulate the spring so that it will not carry the current. The slide or upper carbon holder should occasionally be cleaned with sandpaper, and the tension of the brush spring should be sufficient to make a good contact, care being taken not to make the tension so great as to prevent the carbon from feeding freely. The carbon should rest centrally on the point of the lower electrode. If the lower electrode does not come in line with the carbon the lower electrode holder should be bent over sufficiently to bring them in line.

Polarity

It is good practice to bend over the end of the positive wire, leaving the end of the negative wire straight. While no ill effect will result from reversal of polarity with the incandescent headlight, the same precautions should be carried out to avoid confusion in tracing connections.

Concluding the arc lamp inspection, care should be taken to see that all connections are tight and that the lamp base fits snug in the slots of the case, so as to prevent vibration when the locomotive is in motion.

Incandescent Headlight

The incandescent type "C" concentrated filament lamp greatly simplifies the maintenance of the headlight. However, to obtain economical operation careful attention is as important with this type as it is with the arc lamp. The normal life of this type lamp under favorable conditions will be approximately 1,000 burning hours. To obtain the normal life, among the most important points, is to see that the turbine governors are kept in a first class condition to insure against excessive speed and voltage. In order that the lamp will not be broken by mechanical injury, care must be taken to have all parts of headlight perfectly tight and secure. As the temperature of the lamp is very high, precaution must be taken to see that it is protected from the weather. The temperature of the lamp being high, excessive temperature, caused by imperfect contacts, must be guarded against. Poor contacts, if permitted to exist, will also destroy the lamp socket and the lamp base.

To avoid this trouble, the lamp and socket contact points should be inspected each trip and cleaned if necessary. All other contacts must be kept clean and tight, especially automatic electric headlight case contacts, since the latter mentioned contacts are liable to be sprung by vibration between lamp stand and case.

Cleaning Reflectors

When a reflector is placed in the headlight case it should be carefully and securely fastened with the flange screws, and reflector should be maintained in a clean condition at all times. If the reflector is only slightly dirty it may be cleaned by carefully rubbing or stroking in and out from the center to the rim, with soft white waste, using enough pressure of the hand to secure a good polish. In case the reflector is quite dirty, it will be necessary to use polish for cleaning. If the cleanser is in cake form it should be pulverized, dampened and carefully spread over the reflector with a soft cloth or white waste, and allowed to dry. After it is dry, take a clean, dry piece of soft cloth or white waste, and use a rubbing stroke in and out from center to rim, with sufficient hand pressure to secure a good polish. The white cloth or waste that is used for applying the polish should be carefully rinsed out each day in order to prevent accumulation of grit, which will scratch the reflector and spoil the reflecting surface. Switch locomotives equipped with deflectors or reflectors for the purpose of illuminating the foot boards must be maintained in a clean and first-class condition at all times.

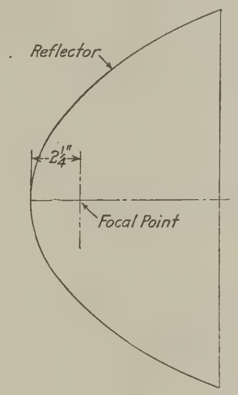


Fig. 2.—Parabolic Reflector Showing Focal Length for Standard 9 In. by 18 in. Reflector

In order to secure a good beam of light it is necessary that the reflectors be at all times maintained in a first-class condition. They should be carefully handled to prevent scratching or denting, as this largely destroys their reflecting capacity. Ordinarily a reflector on an arc headlight lamp should give 12 months' service before a sufficient amount of the silver is lost to seriously reduce its reflecting capacity. Reflectors on incandescent headlights should give much longer service than this.

Focusing of Headlight

The lamp focusing is one of the most important adjustments about the headlight equipment, for if the light source is not in the focal point of the reflector, a good light cannot be obtained. The light from the light source is directed by the parabolic reflector. When the light source is properly placed within it, a reflector of this type has the property of projecting all of the light in parallel rays, or in a beam. It is evident that in order to have a good headlight the light source must be in the focal point of the reflector, which is on a line in the center of the reflector and out from the back, a certain distance, depending on the diameter and depth. Referring to Fig. 2 it will be noted that the focal point is shown on a line in the center of the reflector and 2¼ in. out from the back. This sketch represents a 9 in. by 18 in. reflector, and 2½ in. is the focal length for this size reflector. The focal dimensions for various sizes of reflectors is given in the following table:

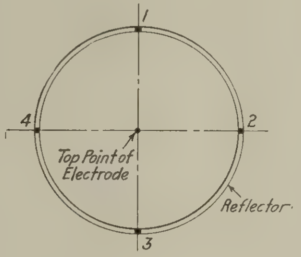


Fig. 3.—Points From Which Measurements Should Be Taken to Center the Light Source in Reflector

Size of Reflector	*Focal Length*
16 in. by 8 in.	2⅜ in.
17½ in. by 10½ in.	1⅝ in.
18 in. by 8¾ in.	2 3/16 in.
18 in. by 9 in.	2¼ in.
18 in. by 12 in.	1¾ in.
23 in. by 14 in.	2⅛ in.

In order to locate the arc in this point in the reflector proceed as follows: Place the arc lamp in position with the upper carbon holder with carbon and electrode holder and electrode in place. Take a rule and measure from top of electrode to top edge of reflector, and from end of reflector to bottom edge of reflector, as shown in Fig. 3. The distance from the end of the electrode to the edge of the reflector should be the same at points 1, 2, 3 and 4. If these measurements are found to be unequal, the lamp should be shifted on the base until the measurements are all the same. Next, before tightening the lamp, measure from back of the reflector to the point of the electrode to see that it is out the proper distance, which is 2¼ in. for a 9 in. by 18 in. reflector. See table for other sizes of reflectors.

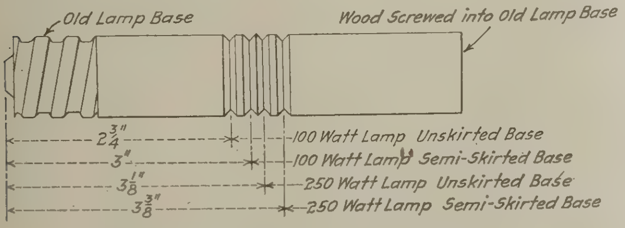

Old Lamp Base
Wood Screwed into Old Lamp Base
2¾"
3"
3⅛"
3⅜"
100 Watt Lamp Unskirted Base
100 Watt Lamp Semi-Skirted Base
250 Watt Lamp Unskirted Base
250 Watt Lamp Semi-Skirted Base

Fig. 4.—Incandescent Lamp Focusing Gauge

In order that the center of the arc will be in the focal point, it will be necessary to lower the arc a distance equal to one-half the length of the arc, which will be approximately 3/32 in. When this is done tighten the lock nuts and then check the measurements to see that the lamp was not moved. If afterwards it is found that the light is not on the track, shift the case, but do not change the adjustments. If the beam is thrown on track too close to the locomotive, raise the front of the case, or lower the back. If the beam is thrown on the track too far ahead of the locomotive, raise the back of the case or lower the front. If the beam is thrown to one side of the track, turn the case until the beam is brought in line with the straight track.

After adjustments have been made, care should be taken to see that no part of the lamp comes in contact with the reflector, so as to cause grounds.

The incandescent type of headlight will be found much easier to focus, and after once being properly adjusted, it will not be necessary to check the focus except after making repairs which required the adjusting screws to be loosened, or incandescent lamp is changed.

There is no adjustment for raising or lowering the back end of the reflector, as there is with the arc headlight. Care should be exercised when assembling to see that the front of the reflector and base are absolutely at right angles to each other. To do this it may be necessary to use shims between the lamp stand and the base. The ordinary square can be used to good advantage to check this adjustment.

A gauge such as shown in Fig. 4 is used to locate the center of the lamp filament in the focal point of the reflector. The distance from the tip of the lamp base to the center of the lamp filament varies as follows:

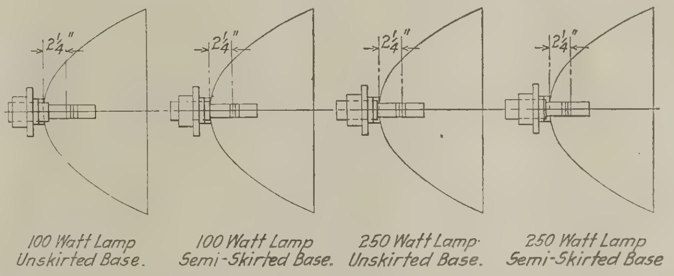

2¼"
2¼"
2¼"
2¼"
100 Watt Lamp Unskirted Base.
100 Watt Lamp Semi-Skirted Base.
250 Watt Lamp Unskirted Base.
250 Watt Lamp Semi-Skirted Base

Fig. 5.—Proper Location for Lamps Showing Method of Using Gauge

2¾ in. for G-25 100 watt, unskirted base.
3 in. for G.25 100 watt, semi-skirted base.
3⅛ in. for G-30 250 watt, unskirted base.
3⅜ in for G-30 250 watt, semi-skirted base.

This gauge is to be used as shown in Fig. 5. The dimension of 2¼ in. should be maintained between the indicated mark on the gauge and the back of reflector, according to the lamp used; that is, each line indicated on the gauge should always be 2¼ in. from the back of the reflector.

Whenever it is possible the incandescent headlight should be focused at night with the locomotive on straight track. If the beam of light is not properly located, it will be necessary to shift the case, in the same manner as with the arc light. Where this is not possible, a fair focus may be obtained by removing the lamp with reflector from the case and making temporary electrical connections to permit the light to be thrown upon a wall approximately 50 ft. away. The light will be in focus when a perfect light circle has been obtained and when the light circle has been reduced to its smallest possible size.

Test for Governor Action

On any type of turbo-generator, especially when used in connection with an incandescent headlight, in order to determine whether or not the turbine governor is working freely, as well as to exercise the governor mechanism, a load should be thrown "on" and "off" the turbo-generator, a number of times, approximately every other trip. This should be done as follows:

Disconnect the entire normal load at the generator in order that the lamps will not be subjected to sudden voltage changes which may cause them to burn out. With the throttle wide open, provide a proper load to cause an extreme travel of the governor in the open position. To do this the resistance unit shown in Fig. 6 should be connected to the positive and negative binding posts until the speed has decreased sufficiently to cause the maximum valve opening. The unit should then be disconnected until the speed has attained its maximum, which will cause the valve to practically close and give the minimum opening. By repeating this operation a number of times and observing the speed changes, it will be noted whether or not the governor and the valve are acting freely. In many cases this operation will assist in removing binding caused by scale, etc. In case it is found that the valve is not working freely it should be given immediate attention.

Governor Failure En Route

In cases where the engineman finds that the turbine speed is excessive, which can be noticed by the sound of the turbine, the brilliancy of the cab lamps, and, sometimes, by the green light emitted from the arc lamp, he should throttle down the turbine speed by use of the globe valve in the cab and endeavor to control the speed in that way. Upon arrival at the terminal he should report the trouble to the roundhouse forces in order that proper repairs may be made before the locomotive is sent out again.

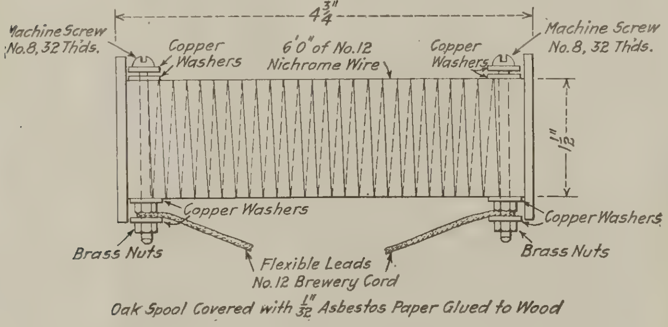

$4\frac{3}{4}''$
Machine Screw No.8, 32 Th'ds.
Copper Washers
6'0" of No.12 Nichrome Wire
Copper Washers
Machine Screw No.8, 32 Th'ds.
$1\frac{1}{2}''$
Copper Washers
Copper Washers
Brass Nuts
Brass Nuts
Flexible Leads No.12 Brewery Cord
Oak Spool Covered with $\frac{1}{32}''$ Asbestos Paper Glued to Wood

Fig. 6.—Resistance Unit For Testing Governor Action

The fact that the arc is burning green is not always an indication of excessive speed, as this is sometimes caused by the wrong connecting of the lead wires from the dynamo to the lamp. However, it can easily be ascertained which trouble is causing the lamp to burn green. If by throttling down as much as possible without extinguishing the arc, the lamp still continues to burn green, it is very probable that the trouble is caused by reversed connections and not by excessive speed. This can be remedied by reversing the connections at the lamp. If when throttled down to proper speed the lamp no longer burns green, it may be taken for granted that the trouble was due to excessive speed, and the equipment can be handled accordingly.

With the incandescent headlight the engineer will not be able to detect high speed and consequently high voltage by the lamp burning green, as the only indication of high speed will be an increased brilliancy of the headlight and cab lights. If the sound of the turbine or the brilliancy of the cab lamps indicate excessive speed, the engineer should throttle the turbine to give as near the proper speed as is possible for him to determine, in order that the headlight lamp will not be burned out.

Suggestions for Locating Headlight Trouble

Should a headlight be reported as failing, the best procedure to follow will be to see that the steam has a free passage to the turbine governor and is not obstructed by an accumulation of pipe scale or other foreign substances. On the Pyle type "C" this may be done by removing the plug in the top of the casing, and on the Pyle type "E" by removing the governor valve cap, after which any scale may be blown out by turning on the steam. If the steam passage should be found to be open, the strainers should next be examined and cleaned if found to be dirty.

After admission of the steam to the turbine has been assured the turbines should be allowed to run, to determine whether the governor is working freely. The test for the governor action should be made as previously described.

Testing for Grounds

If the turbine appears to be in working order, the electrical unit should next be examined by first ringing the entire system for grounds. If a ground exists the various parts of the electrical system should be tested separately. The armature should first be tested by removing the brushes and connecting magneto wires from segment on commutator to dynamo frame. If the armature is free of grounds, disconnect wiring leading to dynamo and replace brushes on commutator; again test from commutator to ground. If a ground exists, the brush holders and fields must then be tested separately. If the dynamo is clear of grounds, the magneto leads should then be connected between the wiring system and the ground. If a ground exists it will be necessary to test the various circuits separately. If a circuit is grounded, to determine the exact location the units forming a part of the circuits should be tested separately.

Testing for Short Circuit

If the system is clear of any grounds, an examination and test may be made for a short circuit. As it is sometimes difficult to detect a shorted coil in an armature, the best practice will be to try a new armature which has been tested.

If the test indicates that the generating unit is in good order, proceed to make test for open or shorted circuit. To locate a short in a circuit the best practice will be to disconnect each circuit at the point where the circuit receives its power. The lamps or other devices consuming power should then be removed or disconnected.

The magneto wire may then be connected to the circuit, which should test clear. If the magneto indicates a short circuit, the various drops or outlets must then be disconnected, making a test each time a unit is disconnected until the short circuit is removed. When this is done the last part removed will of course contain the short.

Testing for Open Circuit

To locate a broken wire disconnect the various circuits, the same as for locating a short circuit. Ground both wires at one end of the circuit, making test from other end of circuit by connecting one magneto wire to ground, and the other magneto wire to the wire being tested. The broken wire will test clear—that is, the magneto will not ring. If, however, the wire is not broken, a current will pass over the wire through the ground back to the magneto and cause it to ring.

If the dynamo refuses to build up when it is known that the armature and fields are O. K., and all connections properly made, it may be found that the pole pieces have lost their residual magnetism. This may be regained by connecting at least three dry cells in series to the machine, as follows:

Series Dynamo.—Have the dynamo running with the top brush lifted from the commutator. Connect the positive battery lead to the top brush holder, connecting the negative battery lead to the positive bottom right hand binding post. In a few moments the battery may be disconnected and the brush lowered into position, when dynamo should build up.

Compound Dynamo.—For a compound dynamo proceed the same as for the series dynamo, except that the negative battery lead must be connected to the bottom brush holder proper instead of the positive binding post.

Railroad Electrification Facts and Factors

A Study of Energy Lost in Accelerating Electric Locomotives by Various Methods of Control

By A. J. Manson*

LAST month we described the different methods used to gradually increase the voltage to the motors, by the cutting in or out of resistance, and also discussed the different motor arrangements. The different methods used to change from series to parallel were taken up and it was shown how with the "Bridging Method of Transition" it is possible to get the motors from start to full parallel with a constant tractive effort.

Mention was made in describing the rheostatic control that the arrangement was not economical, that the resistance loss was excessive but could be cut down by connecting the motors in combinations. The saving in power that can be gained by connecting the motors in combinations is shown herewith. It is impossible to avoid rheostatic losses entirely but they can be considerably reduced.

Assume that a locomotive is equipped with four motors to operate from a third rail at 650 volts. It will require a thousand amperes per motor to start up this locomotive coupled to a certain train, and accelerate it up to a certain speed (where all the resistance is cut out) in forty-five seconds.

Energy Losses—Rheostatic Control

We will first consider the rheostatic arrangement where all the motors are connected in parallel and a series resistance is used. Fig. 1 shows the energy lost in the resistance with this arrangement. Each motor takes 1,000 amperes at 650 volts so that the locomotive is taking from the power supply 650 (volts) × (4 × 1,000) (amperes) = 2,6,00,000 watts or 2,600 kilowatts. This number of kilowatts is taken during the straight line acceleration, the resistance being cut out step by step, and is represented by the line *ab*. Forty-five seconds has elapsed during this straight line acceleration so that the energy consumed is represented by the area *oabc* and is 2,600 (kw.) × 45 (sec.) = 117,000 kw. seconds or

$$\frac{17{,}000 \text{ kw. seconds}}{3{,}600 \text{ no. of sec. per hr.}} = 32.5 \text{ kilowatt hrs.}$$

The amount of energy lost in the resistance depends on the product of the current and the difference between the line volts and the motor volts. At any time it is current × line volts — motors volts. A certain voltage is necessary to start the motors and in figuring it is taken as 10 per cent of the line voltage. In our present problem 65 volts would then be required and the kilowatts taken by the motors is

$$\frac{65 \times 4000}{1000} = 260 \text{ kw.}$$

which is shown at point *x*. At the end of 45 seconds all of the resistance has been cut out and the motors are absorbing all of the energy with 650 volts impressed on them. The line *xb*, therefore represents the volts at the motor and also the dividing line between the energy lost in the resistance and that used by the motors. We have just stated above that the loss in the resistance is the current × line volts — motor volts so that the area above the line *xb*, represents the energy lost in the resistance and the area below the line the useful energy absorbed by the motors. Since 10 per cent of the line voltage is taken by the motors at start, 90 per cent of the voltage will be lost in the resistance at start. The average voltage loss, since *xb* is a straight line, will be ½ of this or 45 per cent of the line volts. In this case 45 per cent of 650 volts is 292.5 volts. The same current as taken by the motors, namely 4,000 amperes, flows through the resistance so that the energy loss is 4,000 (amperes) × 292.5 (average volts) × 45 (seconds time power is on) ÷ by 3,600 × 1,000 (number of seconds in an hour to get the results in terms of kilowatt hours) = 14.6 kw. hrs.

---

*Westinghouse Electric Manufacturing Company, New York.

Energy Loss—Series-Parallel Control

We will next consider the series-parallel arrangement where there are two sets of two motors each connected permanently in parallel. In starting up, the two sets are connected in series and instead of 4,000 amperes being taken from the line only 2,000 will be used, although each motor is getting 1,000 amperes and the locomotive is developing the same drawbar pull. At transition the motors are connected four in parallel and 4,000 amperes are again taken from the line. With the motors connected in the series-parallel arrangement there are two motors in series across the line so that as each motor requires its 10 per cent voltage or 65 volts to start up with 1,000 amperes, the voltage used by the motors is 130 volts. There is then 520 volts to be absorbed by the resistance or only 80 per cent. The current from the line at starting is one-half of that of the rheostatic control or 2,000 amperes so that the useful energy is of the same value, namely, 260 kw. and point *x* is located as shown in Fig. 2. The time required to accelerate is the same as before, namely 45 seconds, so that the line *xg*, will be the dividing line between the energy loss in the resistance and the useful energy absorbed by the motors, and is the same line as *xb*, in Fig. 1.

The average voltage loss during series is then one-half of the 80 per cent or 40 per cent of the line volts, or 260 volts. In order to know what the kilowatt hours loss will be during series it is necessary to know at what time the motors will reach full series. The total time will be divided between series and parallel in the ratios of the counter e.m.fs. of the motors in series and in parallel after the resistance is cut out. When the two motors are in series each has one-half of 650 volts or 325 volts across the terminals. As per our assumption of this motor, 65 volts is sufficient to give 1,000 amperes through the motor so that when running without resistance and with 1,000 amperes the back e.m.f. must be 325 — 65 or 260 volts. When the motors are in parallel each motor has 650 volts across the terminals but the same number of volts, namely, 65, gives the 1,000 amperes. The back e.m.f. must then be 650 — 65 or 585 volts. The ratio of 260 to 585 is 0.444. This means that 44.4 per cent of the time is taken in series and 55.6 per cent of the time in parallel. The number of seconds in this problem for the series operation is 44.4 per cent of 45 = 20 seconds. We have shown that the average voltage is 260 volts so that the kilowatt hours energy loss in the resistance in series is

$$\frac{260 \text{ volts} \times 2{,}000 \text{ amperes} \times 20 \text{ seconds}}{3{,}600 \times 1{,}000} = 2.89 \text{ kw. hr.}$$

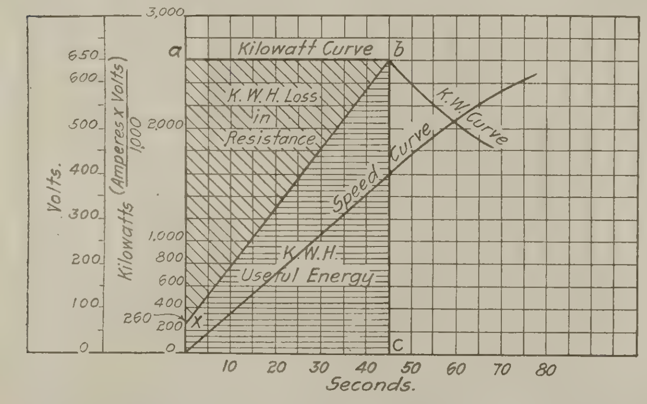


Fig. 1. Energy Consumption and Resistance Losses Rheostatic Control

When the motors are first connected in parallel the voltage across each motor is, of course, one-half of the line voltage or 325 volts, the resistance taking care of the other 50 per cent. This 50 per cent lost in the resistance when transition is made is reduced to no loss when all the resistance is cut out. The average loss in parallel is then 25 per cent or 162.5 volts. The time in parallel is, as we have shown, 55.6 per cent or 25 seconds so that the kw. hrs. loss in parallel is

$$\frac{162.5 \text{ volts} \times 4{,}000 \text{ amps.} \times 25 \text{ seconds}}{3{,}600 \times 1{,}000} = 4.51 \text{ kw. hr.}$$

The total loss in the resistance is 2.89 + 4.51 = 7.40 kw. hrs. The useful energy for the motors has not changed but remains the same at 17.9 kw. hr. The total input then is 17.9 + 7.40 = 25.30 kw. hr. which compared to the rheostatic control shows a saving in the total energy input of approximately 25 per cent.

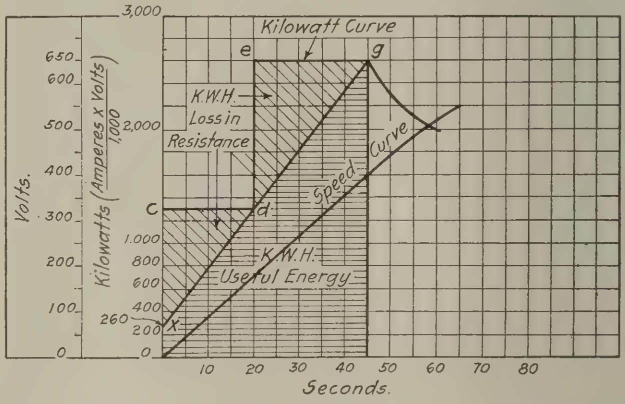


Fig. 2. Energy Consumption and Resistance Losses Series—Parallel Control

Energy Loss—Series, Series Parallel, Parallel Control

A further reduction in total energy consumed by cutting down the resistance loss, can be obtained if the motors are connected first, four in series, then series-parallel and finally all in parallel. With the four motors in series 40 per cent of the voltage is taken by the motors in series so that only 60 per cent or 390 will be lost in the resistance. The average voltage loss during the time for four motors are in series is ½ of 60 or 30 per cent of the line volts which is 195 volts. The time is arrived at as before and is the ratio of the back e.m.f. of the motors when operating without resistance and at the voltages. The back e.m.f. of the motors when connected four in series is $\frac{650 \text{ volts}}{4} - 65 \text{ volts} = 97.5 \text{ volts}$. The back e.m.f. of the motor in the parallel position is, as shown before, 585 volts. The ratio of 97.5 to 585 is 0.166. This means that 16.6 per cent of the time is taken with the four motors in series. In this particular case, where 45 seconds is the total time, the elapsed time is 7.5 seconds.

The total energy at start is 1,000 amperes × 650 volts = 650 kw. Referring to Fig. 3, it is the line *cd*. The saving in energy or saving in loss in the resistance by connecting the four motors in series as the first combination is equal to the area *cdeh*. The area *cdeh* represents $\frac{7.5 \text{ seconds} \times 650 \text{ kw.}}{3,600} = 1.35$ kw. hr., so that the total loss in the resistance is 7.40 — 1.35 = 6.05 and the total energy input will be 25.30 — 1.35 = 23.95. The summary of the foregoing calculations is given in Table 1.

TABLE I.

ENERGY CONSUMPTION AND RESISTANCE LOSSES.

Arrangement	Total Energy Input	Loss in Resistance
Rheostatic	32.5 kw. hr.	14.63 kw. hr.
Series-Parallel	25.30 " "	7.40 " "
Series, Series-Parallel, Parallel	23.95 " "	6.05 " "

Formulae

The foregoing results have been worked out for a specific problem but since definite percentages of time are required to reach the transition points it is possible to give formulas so that any problem can be worked out rapidly without going through all of the above calculations. These formulæ are as follows:

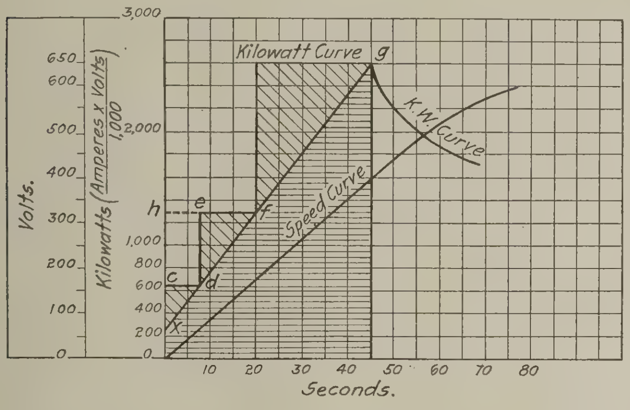


Fig. 3. Energy Consumption and Resistance Losses. Series—Series Parallel—Parallel Control

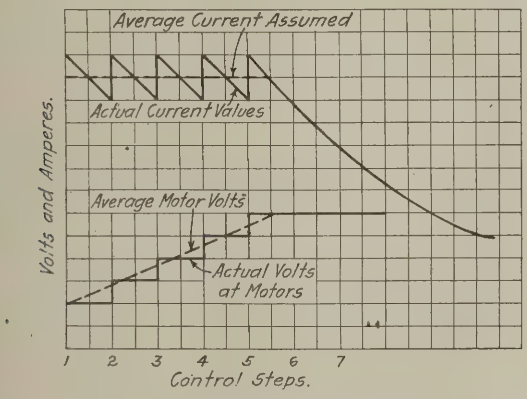


Fig. 4. How the Current and Voltage Changes at the Motors as the Control is Operated

Let A = accelerating or starting current per motor
" V = trolley voltage
" T = time in seconds to reach speed with all resistance cut out and motors in full parallel
" W = watt seconds taken from the line
" W/R = watt seconds lost in resistance
" W/M = watt seconds used by motors

RHEOSTATIC CONTROL

$W = 4\ A\ V\ T$

$W/R = 4\ A \times 0.45\ V \times T = 1.8\ A\ V\ T$

$W/M = W - W/R = 2.2\ A\ V\ T$

SERIES-PARALLEL CONTROL

$W = 2\ A\ V \times 0.444\ T + 4\ A\ V \times 0.556\ T = 3.111\ A\ V\ T$

$W/R = 2\ A \times 0.4\ V \times 0.444\ T + 4\ A \times 0.25\ V \times 0.556\ T = 0.911\ T$

$W/M = W - W/R = 2.2\ A\ V\ T$

SERIES, SERIES PARALLEL, PARALLEL

$W = A\ V \times 0.166\ T + 2\ A\ V \times 0.278\ T + 4\ A\ V \times 0.0556\ T = 2.945\ A\ V\ T$

$W/R = 0.911\ A\ V\ T - 0.166\ A\ V\ T = 0.745\ A\ V\ T$

$W/M = W - W/R = 2.2$

The above formulæ cover a four motor equipment. If two motors were being considered the values would be one half.

Notching Diagram

The Figs. 1, 2 and 3 are drawn assuming that the current, hence the watts input, is constant and that the voltage at the motors varies continuously. For general calculations this assumption is correct as the average values can be assumed. Actually there is a variation in the current. When a step of resistance is cut out the current jumps up as as additional voltage is applied to the motor. With the increase in voltage the motor speeds up, the back electromotive force increases and the current becomes less. Fig. 4 shows, approximately, how the current and the voltage changes at the motors as the control is operated. It also illustrates the rheostatic control, but the same holds true for the other motor arrangements. The curves shown in Figs. 1, 2, and 3 are kilowatt curves and for exact calculations should be drawn as is the current curve in Fig. 4. The line voltage is constant so that the watts vary as the current and the current curve, Fig. 4, represents also the kilowatt curve.

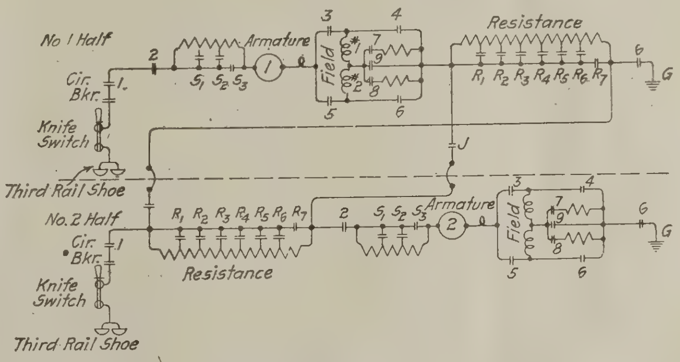


Fig. 5. Schematic Diagram of Pennsylvania Passenger Locomotive Showing Field Control Connections

Field Control

There is another method of still further reducing the energy loss in the resistance and obtaining more efficient operation. This method is field control, which regulates the speed of the motor by varying the effective field turns. This arrangement is most desirable for locomotives. Field control has been applied to the a. c.—d.c. passenger locomotives in use on the New Haven railroad. The large Pennsylvania locomotives operating through the tunnels into New York City have used field control to the greatest advantage.

The field control motor has two sets of field windings. In large motors these windings are separate, but in smaller motors there may be only one set of field coils with a tap, so that if connection is made to the tap lead only a part of the field turns will be used. When starting up all of the field will be in the circuit. The motor will have an extra strong field due to the extra number of turns of wire around the poles so that for the same acceleration, i. e., the same tractive effort, less current is required. Less current is required to give the same ampere turns and hence field strength.

In a series motor the field strength determines the speed, so that with the stronger or full field the speed will be lower. Lower current means a reduction in the resistance losses and a slower speed means that the resistance is cut out sooner which also reduces the losses. To get the motor up to the same speed as the non-field control motor, some of the field turns are cut out of the circuit, the field is weakened and thus the motor speeds up. This change to the "short field" is made without main resistance losses. A great advantage of field control is that many economical running speeds are available. Take the four motor locomotives; with series-parallel arrangement of motors there are normally only two running speeds—series and parallel,—but with field control motors there would be four speeds, two in series and two in parallel. One of the "series" speeds would be with the motors running on full speed and the other with the motors running on short field. The same is true for the two speeds in parallel.

As mentioned above the Pennsylvania electric locomotives operating into the terminal New York City are a fine example of what can be accomplished by field control. Each motor, of which there are two, weighs approximately 44,000 lbs. The step from "full field" to "short field" is not made in one jump, but by three steps. The first two field steps put resistance in parallel with the field, shunting away some of the current and thus weakening the field. The third step cuts out half of the field. During acceleration the energy saved by the field control is 45 per cent of that which would be consumed if field control was not used. Moreover the speed increases from full field to short field when the locomotive is exerting approximately 20,000 lb. drawbar pull, by as much as 37 per cent. The schematic diagram of the main circuits of the locomotive, together with the sequence of switches are shown by Figs. 5 and 6. It is nearly as simple as the diagram used in the last issue to illustrate "Bridging Control." There are a few more resistance steps and, of course, the added feature of field control. Referring to Fig. 6, the field variation is obtained, for the No. 1 motor, by closing the switches Nos. 7, 8 and 9. The other four switches of the field group, namely Nos. 3, 4, 5 and 6, are to regulate the direction of flow of the current through the fields and hence the direction of rotation of the motor. When switches No. 3 and No. 6 are closed the current flows through both the No. 1 and No. 2 field coils in one direction and in the opposite direction if switches No. 4 and No. 5 are closed.

	Steps	No. 1 Half												Sequence of Switches																								No. 2 Half										Steps
		C.B.	1	2	3	4	5	6	7	8	9	J	G	S_1	S_2	S_3	R_1	R_2	R_3	R_4	R_5	R_6	R_7	C.B.	1	2	3	4	5	6	7	8	9	J	G	S_1	S_2	S_3	R_1	R_2	R_3	R_4	R_5	R_6	R_7	
	Off																																												Off
	1	O	O	O		O	O																	O		O	O			O				O	O											1
	2	O	O	O		O	O							O										O		O	O			O				O	O	O										2
	3	O	O	O		O	O							O	O									O		O	O			O				O	O	O	O									3
	4	O	O	O		O	O							O	O	O								O		O	O			O				O	O	O	O	O								4
	5	O	O	O		O	O									O	O							O		O	O			O				O	O			O	O							5
	6	O	O	O		O	O									O	O	O						O		O	O			O				O	O			O	O	O						6
	7	O	O	O		O	O									O	O	O	O					O		O	O			O				O	O			O	O	O	O					7
	8	O	O	O		O	O									O	O	O	O	O				O		O	O			O				O	O			O	O	O	O	O				8
	9	O	O	O		O	O									O	O	O	O	O	O			O		O	O			O				O	O			O	O	O	O	O	O			9
	10	O	O	O		O	O									O	O	O	O	O	O	O		O		O	O			O				O	O			O	O	O	O	O	O	O		10
Series F.F.	11	O	O	O		O	O					O				O						O		O		O	O			O				O	O			O						O		11
	12	O	O	O		O	O		O			O				O								O		O	O			O	O				O			O							O	12
	13	O	O	O		O	O		O	O		O				O								O		O	O			O	O	O			O			O							O	13
Series N.F.	14	O	O	O			O		O	O	O	O				O								O		O	O				O	O	O		O			O							O	14
	15	O	O	O		O	O					O				O								O		O	O			O					O			O								15
	16	O	O	O		O	O					O				O								O		O	O			O					O			O								16
	17	O	O	O		O	O					O	O			O								O	O	O	O			O					O			O								17
	18	O	O	O		O	O					O	O			O								O	O	O	O			O					O			O								18
	19	O	O	O		O	O						O			O								O	O	O	O			O					O			O								19
	20	O	O	O		O	O						O			O	O							O	O	O	O			O					O			O	O							20
	21	O	O	O		O	O						O			O	O	O						O	O	O	O			O					O			O	O	O						21
	22	O	O	O		O	O						O			O	O	O	O					O	O	O	O			O					O			O	O	O	O					22
	23	O	O	O		O	O						O			O	O	O	O	O				O	O	O	O			O					O			O	O	O	O	O				23
	24	O	O	O		O	O						O			O	O	O	O	O	O			O	O	O	O			O					O			O	O	O	O	O	O			24
	25	O	O	O		O	O						O			O	O	O	O	O	O	O		O	O	O	O			O					O			O	O	O	O	O	O	O		25
Parallel F.F.	26	O	O	O		O	O						O			O						O	O	O	O	O	O			O					O			O						O	O	26
	27	O	O	O		O	O		O				O			O						O	O	O	O	O	O			O	O				O			O						O	O	27
	28	O	O	O		O	O		O	O			O			O						O	O	O	O	O	O			O	O	O			O			O						O	O	28
Parallel N.F.	29	O	O	O			O		O	O	O		O			O						O	O	O	O	O	O				O	O	O		O			O						O	O	29
		C.B.	1	2	3	4	5	6	7	8	9	J	G	S_1	S_2	S_3	R_1	R_2	R_3	R_4	R_5	R_6	R_7	C.B.	1	2	3	4	5	6	7	8	9	J	G	S_1	S_2	S_3	R_1	R_2	R_3	R_4	R_5	R_6	R_7	

Fig. 6. Sequence of Switches for Diagram in Fig. 5

Assuming that switches No. 3 and No. 6 are closed the field control is obtained as follows: First switch No. 7 closes. A resistance is connected in the circuit and shunts away from field No. 2 part of the current which has passed through field No. 1. The total field strength has therefore been weakened and the locomotive speeds up. Switch No. 8 is closed next and more current is shunted away from the field No. 2. The next step consists of the closing of switch No. 9 which cuts out field No. 2 entirely.

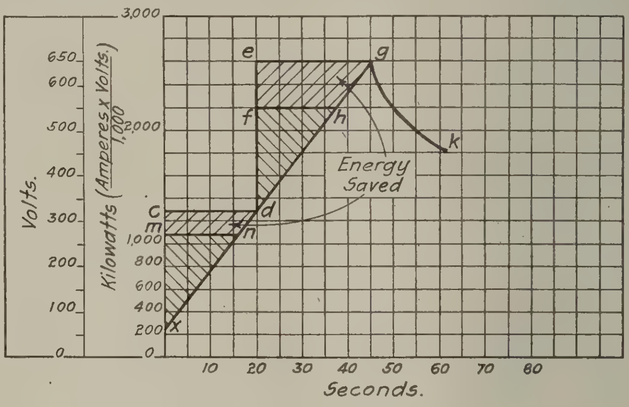


Fig. 7. Energy Consumption and Resistance Losses Field Control

As mentioned above the saving due to field control is on account of less resistance being required and a lower accelerating current. Referring to Fig. 7 the kilowatt curve, *c d e g k,* is the kilowatt curve of the locomotive without field control and is the same curve as Fig. 2. With field control the kilowatt curve in series will be *mn,* instead of *cd,* and in parallel *fh,* instead of *eg.* The kilowatt curve with field control is then *m n d f h g k,* and the saving of energy is represented by the areas as shown.

All of the above discussion has been on 600 volts direct current locomotives. In general the same holds true for the high voltage direct-current locomotives. There are, however, special features, which distinguish the latter, especially as regards circuits and arrangement of motors.

A Record for Wireless Transmission between an airplane in flight and a land station was recently made during maneuvers of the Thirty-seventh Infantry. Signals sent from a plane at Fort Mackintosh were recorded at Del Rio, Texas, a distance of 175 miles.

The City of Milwaukee is planning to build its own electric plant to supply current for operating the proposed sewage disposal plant on Jones Island. The electric plant will have a capacity of approximately 8,800 kilowatts. It is estimated that the city will save $60,000 a year by operating its own plant instead of buying power from the electric company.

Electric Arc Welding in Railroad Maintenance*

Many Worn Out and Broken Parts Have Been Recovered for Further Use by Applying This Process

By E. Wanamaker and H. R. Pennington

DURING the world's war the railroads of the United States were able to save vast quantities of iron and steel by reclaiming, repairing and returning to service broken and worn parts of railroad equipment. This was accomplished by means of the welding processes. If it had been necessary for the steel mills to replace such material, the production of munitions of war and shipbuilding would have been greatly reduced. Because of the unavoidable circumstances during the emergency period, numerous parts of broken equipment had to be repaired, and in many cases the exact method of applying the welding process had to be developed; consequently the progress in the art was much more rapid than would have been the case during normal times. A few of the many examples of the application of the arc welding process, which aided in reducing the demand for new parts during the war, are included in this article, to show how advantageously this process was and is being used in the maintainence of railroad equipment.

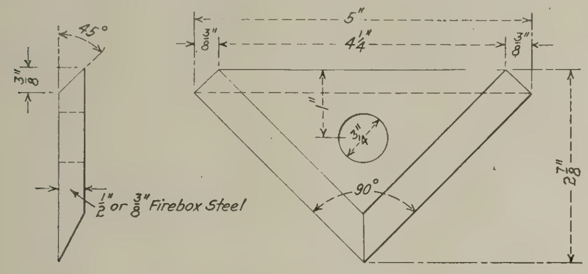


Fig. 1.—Filling Pieces for Five and Six Inch Frames

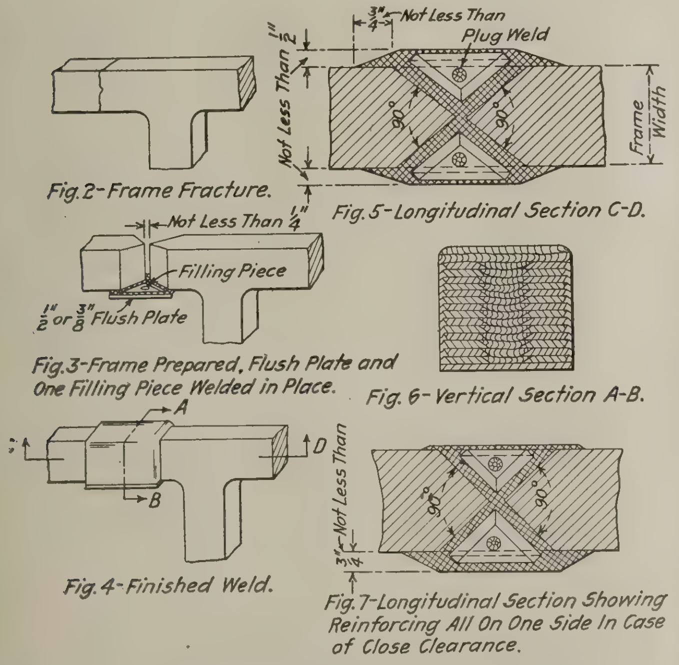
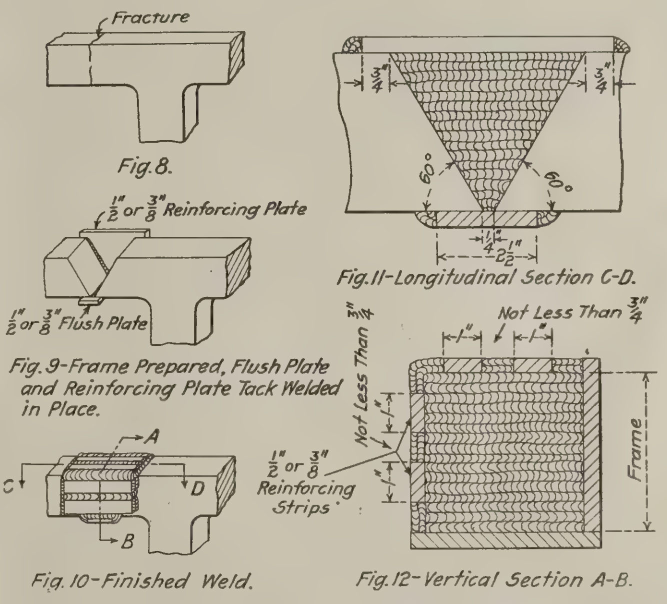


Fig. 2-Frame Fracture.
Fig. 3-Frame Prepared, Flush Plate and One Filling Piece Welded in Place.
Not Less Than 1/4"
Filling Piece
1/2" or 3/8" Flush Plate
Fig. 4-Finished Weld.
A
B
C
D
Fig. 5-Longitudinal Section C-D.
3/4" Not Less Than
Plug Weld
Not Less Than 1/2"
90°
90°
Frame Width
Fig. 6-Vertical Section A-B.
Fig. 7-Longitudinal Section Showing Reinforcing All On One Side In Case of Close Clearance.
Not Less Than 3/4"

Figs. 2 to 7.—Showing Method of Procedure When Work Can Be Done From Both Sides of the Frame

Welding of Locomotive Frame Members and Similar Parts.


Fracture
Fig. 8.
1/2" or 3/8" Reinforcing Plate
1/2" or 3/8" Flush Plate
Fig. 9-Frame Prepared, Flush Plate and Reinforcing Plate Tack Welded in Place.
A
B
C
D
Fig. 10-Finished Weld.
3/4"
3/4"
60°
60°
1/4"
1"
2 1/2"
Fig. 11-Longitudinal Section C-D.
Not Less Than 3/4"
Not Less Than 3/4"
1/2" or 3/8" Reinforcing Strips
1"
1"
Frame
Fig. 12-Vertical Section A-B.

Figs. 8 to 12.—Showing Method of Procedure When Work Can Be Done From Only One Side of the Frame

Broken locomotive frame members have been repaired successfully by means of the arc welding process when the proper methods were used and when reasonable care was exercised by the operator. According to the location of the fracture and the position of the members, the edges to be joined should be beveled as shown in previous articles of this series. Where the oxy-acetylene cutting torch is used to bevel the edges, the film of blue oxide left on the surface by the cutting process must be removed with a chisel, roughing tool or sand blast; otherwise, when the welding is started, the arc will be erratic, which will result in poor penetration and undue oxidation of the added metal. In addition to the cleaning of the surfaces to be joined, the scale which forms on top of the added metal must always be removed before adding one layer to another. Slag inclusions are a common source of weakness in welds, and can be eliminated only by keeping the work perfectly clean as the welding progresses. The electrode material commonly used is mild steel 3/16 in. diameter. Electrodes of ¼ in. may be used if the capacity of the equipment will permit it.

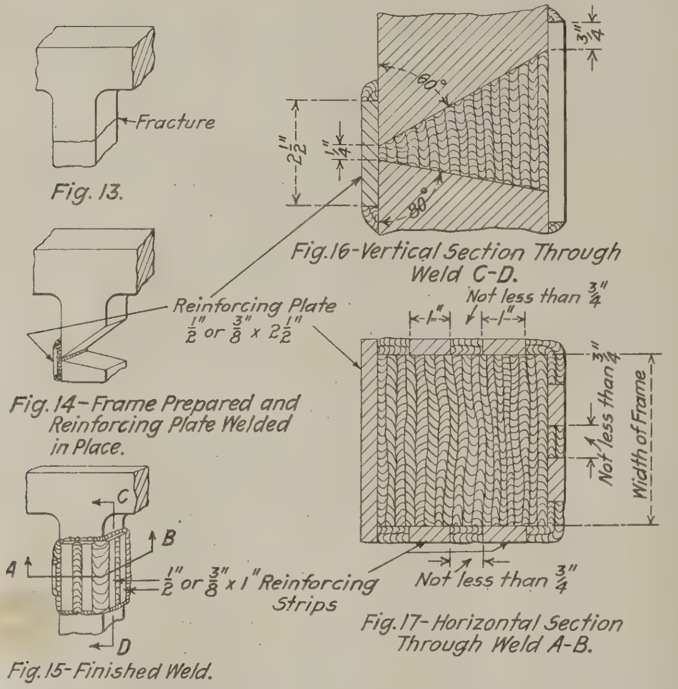
In order to secure proper fusion along the beveled edges through the entire section, access must be pro-

---

*This is the tenth article on Electric Welding by E. Wanamaker, electrical engineer of the Rock Island, and H. R. Pennington, supervisor of welding and electrical equipment, Rock Island Lines. Copyright 1920 by the *Railway Electrical Engineer*.

vided by having large openings on one or both sides of the frame member to be welded. To eliminate the necessity of filling all this opening with metal that has passed through the arc, filling pieces as shown in Fig. 1 are used when conditions permit. The space between the edges of the filling piece and the beveled edges of the frame should not be less than ¼ in.

In executing welds such as shown in Figs. 2 to 7 inclusive, the edges of the flush plate should first be welded to the bottom of the frame. A bead of metal should then be deposited in the corner formed between the top side of the flush plate and the bottom beveled edge of the frame. With a filler piece in place, the plug weld should next be made, then the edges welded to the frame, finishing the welds flush with the top of the piece in order that the next piece will lay close to the preceding one. Additional pieces should be welded in place in the same manner, welding three or four pieces first on one side and then on the other. If the conditions are such that the welding can be done only from one side, the same general method as described above should be used. When the work cannot be done from both sides as just described, the methods shown in Figs. 8 to 12 may be used. The edges of the flush plate, also the reinforcing plate, if access permits its use—should first be welded to the frame. The beveled edges should then be joined by welding metal in the opening until the weld is flush with the opposing members. The reinforcing can then be made by welding on strips, as shown in the illustrations. In place of the plate strips for reinforcing, ½ in. or ⅜ in. rods may be used if desired. Plates wider than 1 in. should not be used unless the surface next to the frame can be welded thereto. Plates wider than 1 in. may be used if provisions are made for plug welds. For frame members the strips or rods are less expensive to prepare and are to be preferred.


Fracture
Fig. 13.
60°
30°
3"/4
2 1/2"
1/4"
Fig. 16-Vertical Section Through Weld C-D.
Reinforcing Plate 1/2" or 3/8" x 2 1/2"
Not less than 3/4"
1"
1"
3"/4
Not less than 3/4"
Width of Frame
Fig. 14-Frame Prepared and Reinforcing Plate Welded in Place.
C
B
A
1/2" or 3/8" x 1" Reinforcing Strips
Not less than 3/4"
D
Fig. 17-Horizontal Section Through Weld A-B.
Fig. 15-Finished Weld.

Figs. 13 to 17.—Showing Method of Procedure in Welding Fractures in Vertical Members

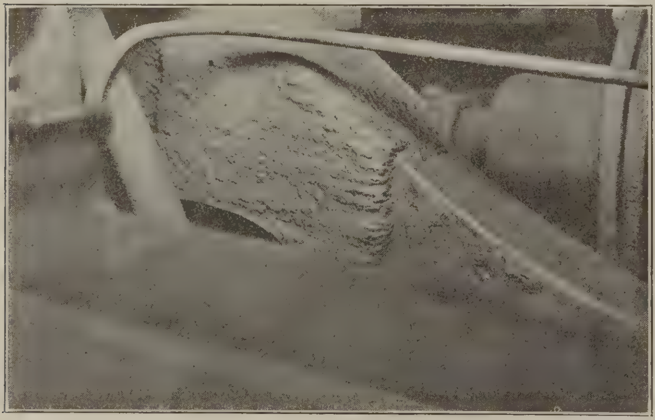


Fig. 18.—A Completed Weld in Locomotive Frame Using Filler Plates

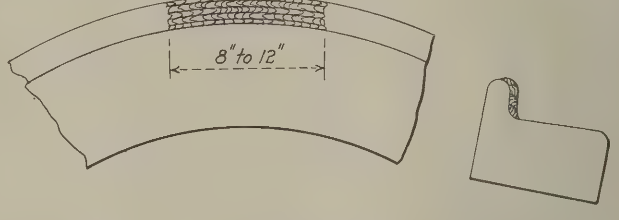


Fig. 19.—Building Up Flanges By Means of Arc Welding Process

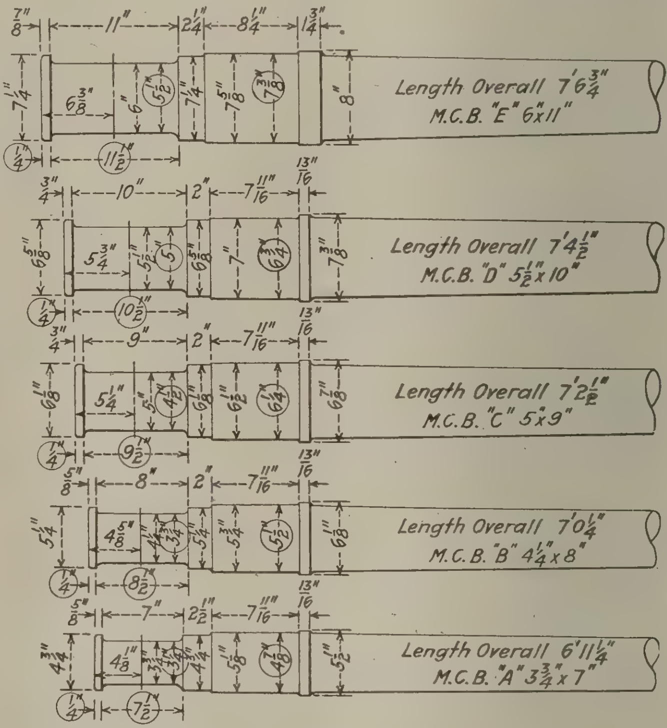


Fig. 20.—Working Standard For Reclaiming Axles By Electric Arc Welding

The welding of vertical members is shown in Figs. 13 to 17. The method of performance is carried on in the same manner as in the case just described. The only difference is that the position of the weld is horizontal instead of flat.

The heat developed by the arc process is so localized that no precautions to resist effects of expansion and contraction are used in the welding of frames. The welding may be continued without interruption, or it may be stopped at any time without fear of breaking after one inch of the opening has been filled.

Extreme care must be exercised to obtain a perfect union between the added metal and the beveled edges of the frame members, also between the added metal and the edges of the filling pieces. The use of the filler plates effects a very large saving in time, and the quality of the weld has proven to be just as good if not better than welds made without the plates. The plates have had mechanical treatment which makes them superior to metal that would ordinarily be added by the arc. If the plates are carried in stock in two or three standard sizes and the frames cut out to accommodate the plates, the largest frame can be welded with the arc welding process in approximately the same time as that required for other processes. For small frames less time may be required. The cost of performing the weld itself has always been in favor of the electric arc process, being on an average of 50 per cent less than that of other methods. The only question which has been raised is that of engine delay in the case of large frames, which can be offset by the use of the filler plates. A finished weld made with filler plates is shown in Fig. 18.

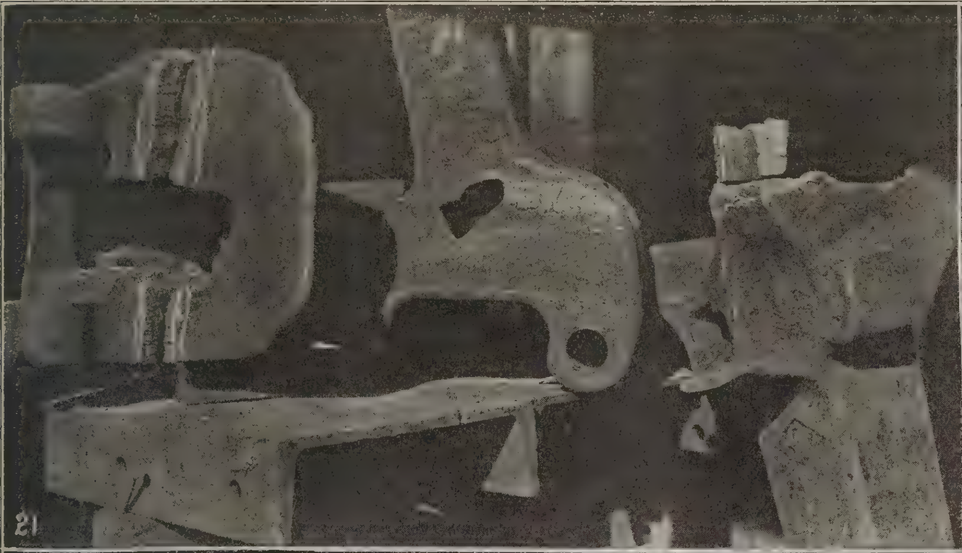


Fig. 21.—Fracture Prepared for Electric Welding

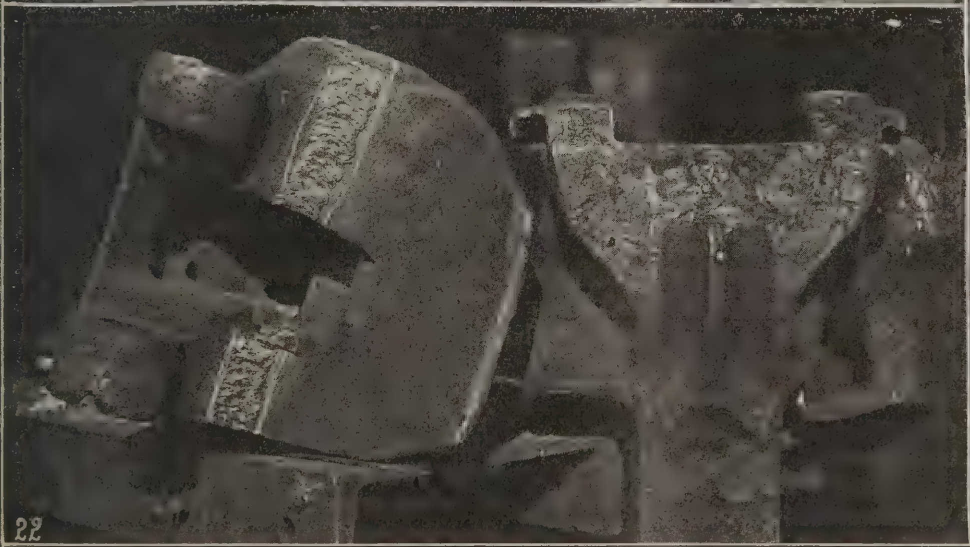


Fig. 22.—Electric Welded Coupler

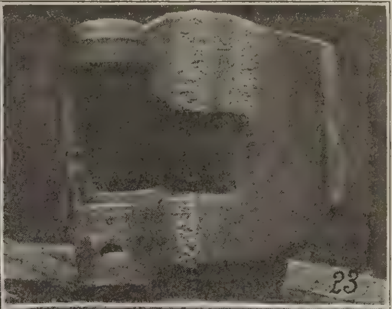


Fig. 23.—A Triple Weld in Face of Coupler

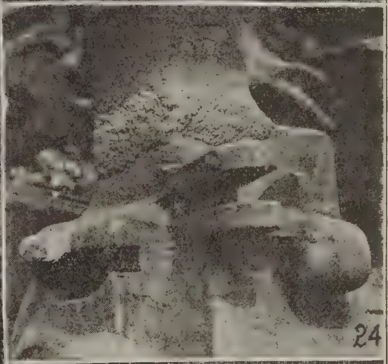


Fig. 24.—An Electric Welded Shank

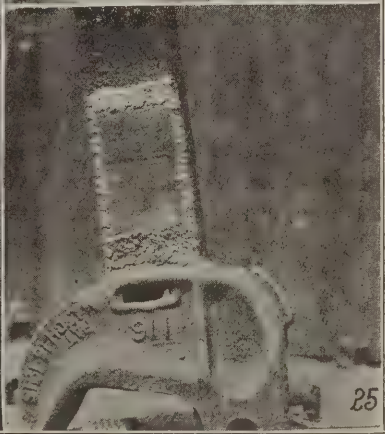


Fig. 25.—Built Up Coupler Shank

Welding Driving Wheels Tires, Rolled Steel Wheels, and Steel Tired Wheels

The arc welding process is extensively used for building up worn flanges and flat spots on driving wheel tires, rolled steel wheels and steel tired wheels. A typical example of the composition of steel tires is shown in the following table:

Manganese, between	.50 per cent and .80 per cent
Phosphorus, not over	.05 per cent
Sulphur, not over	.05 per cent
Silicon, not over	.35 per cent
Carbon (Class 1), not less than..	.50 per cent or over .70 per cent
Carbon (Class 2), not less than..	.60 per cent or over .80 per cent
Carbon (Class 3), not less than..	.70 per cent or over .85 per cent

Class 1.—Driving tires for passenger engines.
Class 2.—driving tires for freight engines and tires for trailer wheels.
Class 3.—Driving tires for switch engines.

Offhand it would not seem legitimate to apply the welding process to a driving flange for fear of the effects of localized heat, which in most cases certainly cannot be ignored. The fact that the practice has been so extensive, without any particular regard for the effects of the heat, and that comparatively few failures have resulted, seems to indicate that many parts (even those high in carbon), under certain conditions, with prescribed methods and limitations, can be safely welded.

The method which is considered the best for building up flanges is shown in Fig. 19. In this case the added metal or beads extend around the periphery of the tire, and is added in sections of 8 to 12 in. long. One section at a time is finished before starting another. The metal can be applied by means of this method more smoothly and with less effort than if the arc is operated back and forth across the flange. The main object in the method described is to keep the arc moving, this preventing the flange from heating to any appreciable depth. This together with the extreme localization of the arc's heat, and the radiating ability of the massive part, will confine the structure disturbance close to the surface, usually to a depth of about ⅛ in., leaving the main body of the flange or tire structure undisturbed. No trouble has been experienced with tires welded in this manner. This probably is due to the fact that the tire is not subjected to alternate stresses. It is believed by those who have analyzed this method, its effects and the nature of the service, that the most that could happen would be for the added metal to shell out. Flat spots are built up in the same general way—i. e., in such a manner as to keep the tire practically cool.

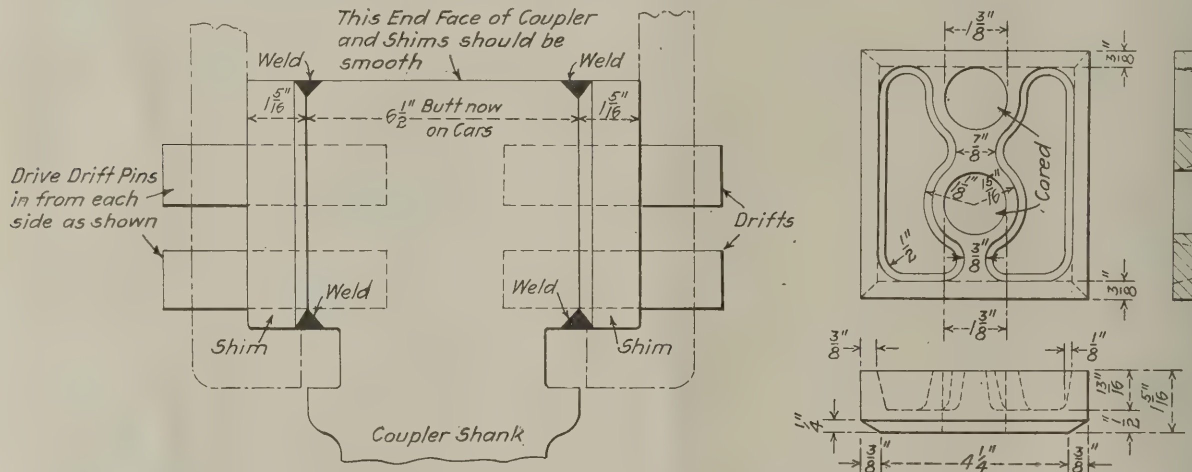


Fig. 26.—Method of Applying Cast Steel Shims to Convert 6½ in. Coupler Shank to 9⅛ in.

A small electrode ⅛ or 5/32 in. in diameter should be used with a heat value as low as consistent with fusion. The composition of the electrode should approximate that of the tire. However, such electrodes cannot be used to advantage unless the material is treated "cooled," so that the constituent parts of the electrode will not be lost in passing through the arc. This feature is important and necessary if the best economy is to be realized from the work. At present practically all of this class of work is being done with the ordinary mild steel. Even with this material much economy is effected.

Reclamation of Axles by Arc Welding Process

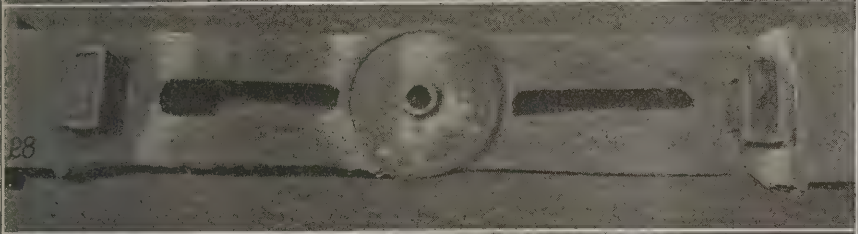
The nature of the service demanded of axles requires prescribed methods and certain limitations if the welding process is to be applied to them. Axles, unlike flanges, are subject to alternate stresses, and therefore cannot be welded except at the collar, unless the effects of the localized heat is afterwards removed by annealing. The practice on one of the western roads is as follows: For reclaiming axles, the standard sizes and limiting dimensions of M. C. B. axles for passenger, freight and tender trucks, as shown in Fig. 20, should be followed. The figures enclosed in circles indicate the limit of wear. Axles condemned for lateral wear occurring at the collar and shoulder of the journal can in most cases be returned to service if *only the collar* is built up and turned to the standard dimensions. Where this is the case, it shall be done and preheating or annealing will not be required. Welding between wheel seats is not permissible. The welding process may be used to build up worn shoulders, or wear caused by dust guard, etc. If facilities are available for annealing after welding, the annealing should be done by heating to a temperature of 1,450 degrees to 1,500 degrees Fahrenheit, which is equal to a bright red color, to be cooled in the open air free from draft, care being taken not to lay on damp ground or cold massive parts such as would tend to chill the axle, which may produce local strains. The 5/32 in. or 3/16 in. No. 1 mild steel coated or uncoated electrode shall be used for this work.

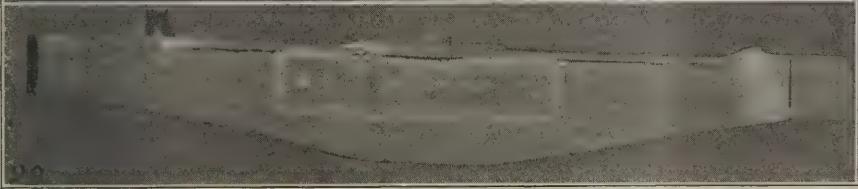
Reclaiming Car Couplers, Knuckles, Etc., By the Metallic Arc Process

On at least one large railroad a vast number of car couplers are being succesfully reclaimed. The work includes not only minor repairs such as building up worn shanks, but also the welding of broken eyes, coupler heads and shanks. The latter class of work is only performed by first-class operators. Treated electrode material is used, i. e., the electrode is coated with a material that prevents oxidation, and prolongs the cooling of the added metal, thus securing a more ductile metal than that obtained from the ordinary bare electrode. In fact, the treated electrode is used for most all important arc welding applications.

In this class of work fractures are cut out in the usual way. A prepared piece of work is illustrated in Fig. 21. Fractures which have been welded and which were of considerable length are shown in the coupler head, Fig. 22. This weld was made in two sections by starting in the center and welding to one end, then starting the second section at the opposite end and finishing at the center, each section being completed before starting another. A triple weld in the face of coupler head is shown in Fig. 23, and Fig. 24 shows a weld extending half way around the shank. These examples represent some of the most severe conditions. In most cases there is only one fracture in the coupler body, the majority being located in the face of the coupler head. A worn coupler shank built up to original size by welding on a piece of steel plate is shown in Fig. 25. Fractured and worn knuckles are repaired or built up in the same general way as couplers. The cost of making such welds is approximately 10 per cent of the cost of new couplers or knuckles.

A method of converting the old 6½ in. coupler butts to the new 9⅛ in. standard is shown in Fig. 26. This is accomplished by applying cast steel shims to increase the dimensions from 6½ to 9⅛ in. One railroad recently converted 8,000 couplers in this manner. The enormous saving effected thereby is apparent.





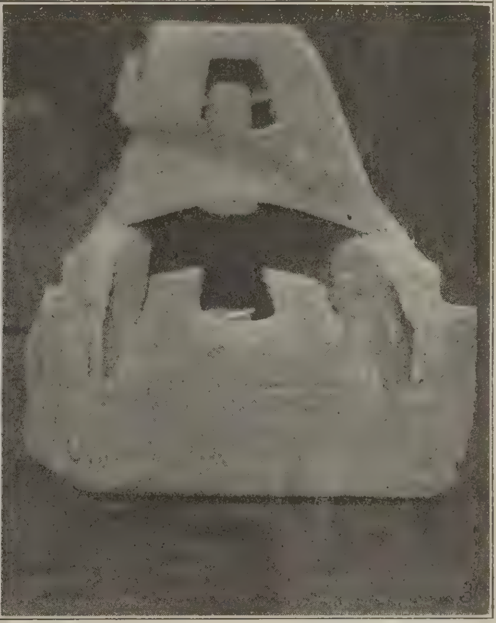


Fig. 27.—Fractured Car Bolster Prepared for Electric Welding
Fig. 28.—Shows the Welded Fracture
Figs. 29 and 30.—Show Manner of Applying Reinforcing Plates

Metallic Arc Welding of Car Bolsters

A fractured car bolster which has been cut out and prepared for welding is shown in Fig. 27. The fractures are welded in the same manner as explained for couplers. In addition, reinforcing plates are applied. The welded fracture is shown in Fig. 28, and in Figs. 29 and 30 is shown the manner of applying the reinforcing plates. When fractured bolsters are received which have previously been repaired by riveting on straps, these straps and rivets are removed and the fracture is welded. The rivet holes are then welded up and a reinforcing plate welded on. The reinforcing is extended over the zone within which the particular class of bolster had indicated a weakness.

The majority of cast steel castings that develop fractures are those which were weak or defective to begin with. A close inspection of a number of such parts will prove this conclusively. Among the most common defects are: air holes, sand pockets and shrinkage cracks. If in repairing such castings these defects are removed, the castings will in many cases be better than they were originally. On one railroad where this practice has been going on for over a year, practically no failures have resulted. In fact, it is almost common practice in many parts of the country to use the arc welding process to repair and reinforce castings and parts in order to add sufficient strength to enable them to withstand the service. Through work of this character the process has acquired the name of the "putting on" tool in some shops.

Some of the parts on which practical applications of this nature have been made are: drawbar castings on Vanderbilt type of tenders for Mikado 2-8-2 locomotives, draft sill end castings on refrigerator cars, locomotive frames, where new and larger cylinders have been applied, cross heads, etc. Space limitations prohibits the mention of the many applications of the arc welding process to machinery parts on railroads. However, some idea as to the extent of its application is given in the list of parts welded which was taken from the records covering a period of 60 days at a division point on one road which has three portable metallic arc welding equipments for locomotive use. During this period a large number of parts of railroad equipment were repaired, as is evident from the list, which is included here because the question has been quite frequently asked, what parts of railroad equipment are electric welded?

List of Parts Electric Welded and Class of Work Performed

Fire Box

Fire door, fracture welded
Fire door, patches welded on
Front flue sheet, fracture welded
Sheets welded to mud ring corners
Side sheets, fracture welded
Side sheets, patches welded on
Side sheets, welded in

Boiler.
Flue sheets, fracture welded
Flues, welded to flue sheet
Superheater pipe, built up.

Frames and Attachments
Belly braces, welded to frame
Binders, built up
Binders, liners welded to binders
Binders, wedge bolt hole plugger
Buckle sheet, holes plugged
Buckle studs, welded to boiler
Bumper castings built up
Cab brackets
Deck casting fracture welded
Equalizer fulcrum arms, fracture welded
Frames, built up
Frames, fracture welded
Frame braces, holes plugged up
Frame braces, welded to frame
Frame jaws, built up
Frame splices, holes plugged up
Front end casting, fracture welded
Guide blocks, built up
Guide yoke, built up
Guide yoke, fracture welded
Guide yoke bracket, fracture welded
Smoke arch brace, fracture welded
Tail pieces, built up

Cylinders
Cylinder, fracture welded
Front cylinder head, fracture welded

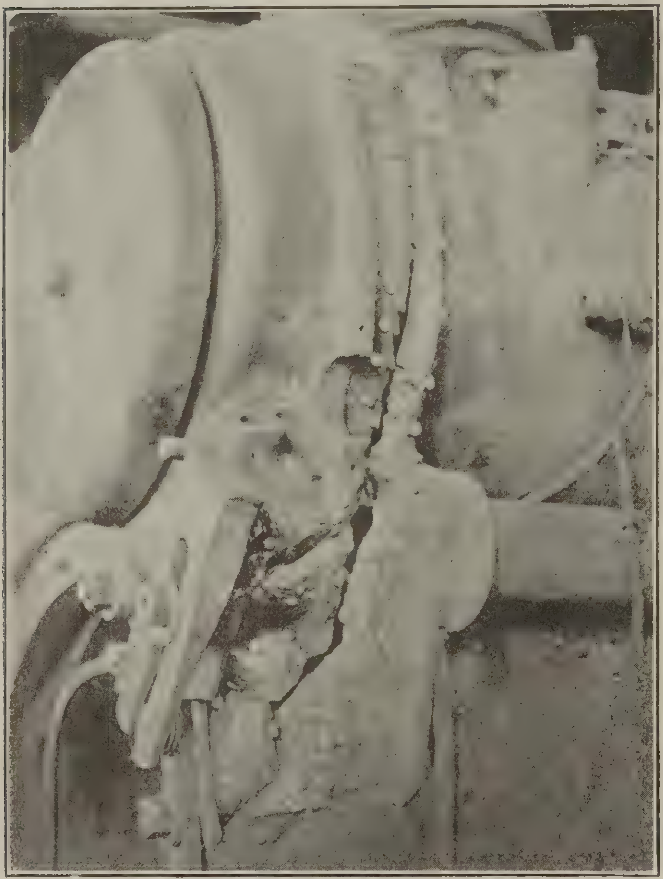


Fig. 31.—Prepared Fractured Cast Iron Cylinder of a 2-8-2 Mikado Type Locomotive For Arc Welding

Running Gear Parts
Crank pins, welding collars to crank pins
Driving boxes, built up
Driving boxes, fracture welded
Driving box, shoes and wedges, welding broken flanges
Engine truck pin, built up
Hub pin, built up
Tires, spots built up
Tires, welding shims to tires
Trailer boxes, lugs welded on boxes
Trailer tires, built up
Trailer tires, fracture welded
Trailer tires, spot welded to wheel center
Trailer yoke
Truck, fracture welded
Truck bolsters, built up
Truck frames, welded to center piece
Truck side frames, fracture welded
Wheel spokes, fracture welded

Connecting Rods
Main rod, built up
Main rod straps, built up

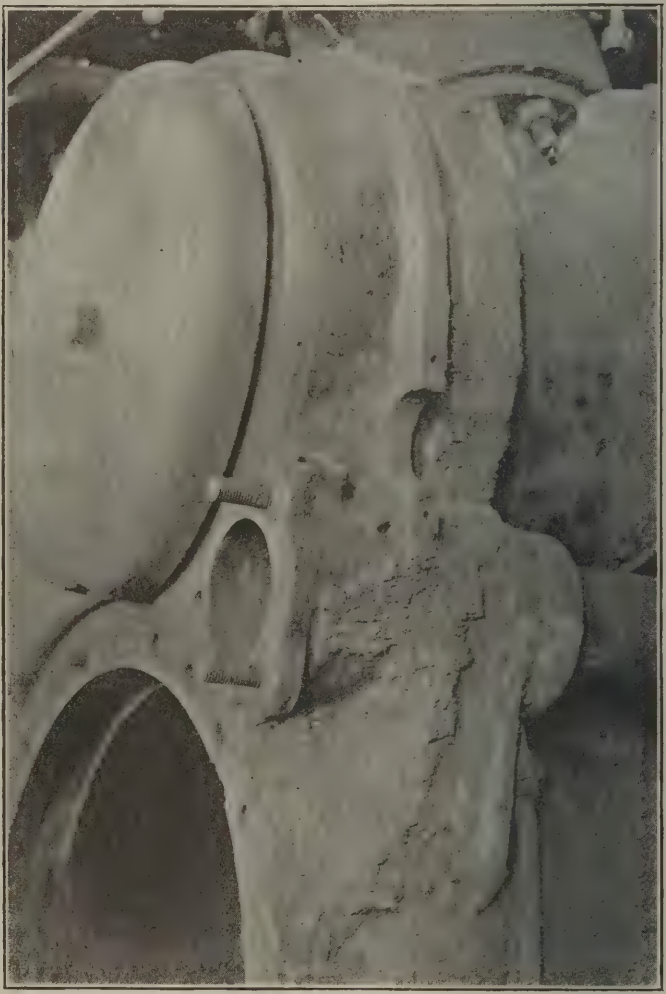


Fig. 32.—Welded Cast Iron Cylinder of a 2-8-2 Mikado Type Locomotive

Rod straps, built up
Rod straps, strips welded to rod straps
Side rods, reinforcing of side rods
Side rods, collar-welded on side rods
Side rods, lateral plates welded on side rods

Cross Heads and Piston Rods
Cross heads, built up
Cross heads, fracture welded
Cross heads, gibs welded on cross heads
Cross heads, holes plugged
Cross heads, liner welded to cross heads
Cross heads, pin built up
Cross heads, pin holes built up
Cross heads, strips welded on cross heads
Piston collar, built up
Piston rod, built up

Valve Gear
Blade pins, built up
Combination lever, fracture welded
Eccentric arms, built up
Eccentric keys, built up
Link, holes plugged
Link blocks, built up
Link hanger, built up

Link pins, built up
Link saddles, built up
Motion pins, built up
Motion plates, fracture welded
Rocker arms, built up
Rocker arms, fracture welded
Tumbling shaft arm, fracture welded
Valve yoke, built up
Valve yoke lugs, built up
Valve yoke, stem built up

Steam and Exhaust Pipes

Dry pipes, fracture welded
Exhaust pipes, fracture welded
Nozzle stands, built up
Nozzle stands, holes plugged

Brake and Spring Rigging

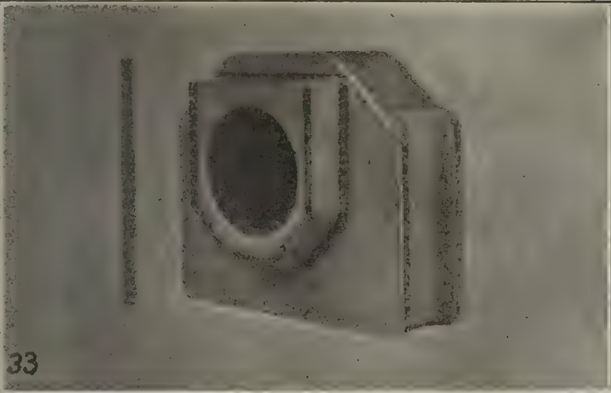
Brake hanger, posts built up
Brake hangers, built up
Brake hangers, welded to frames
Equalizer fulcrum pin, built up
Equalizer jaws, built up
Equalizer stands, built up
Spring equalizer bushing, welded
Spring saddles, built up
Trailer spring guides, built up
Truck equalizer, built up

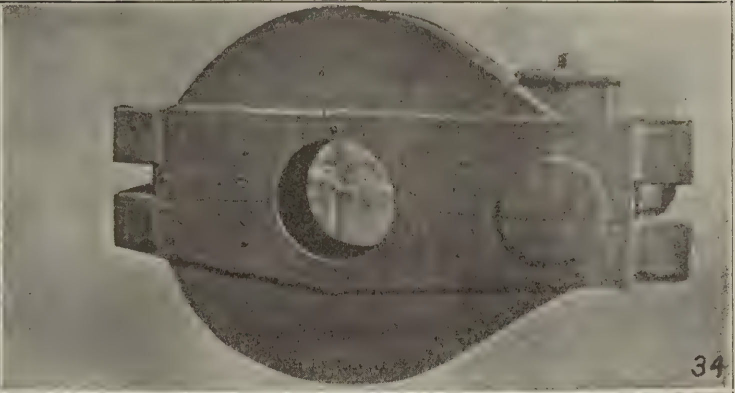
Tender

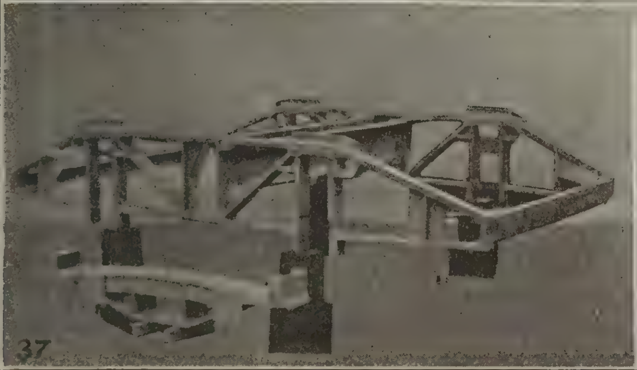
Axle collar, built up
Side bearings, built up
Tank, fracture welded
Tank goose neck
Truck bolster, fracture welded

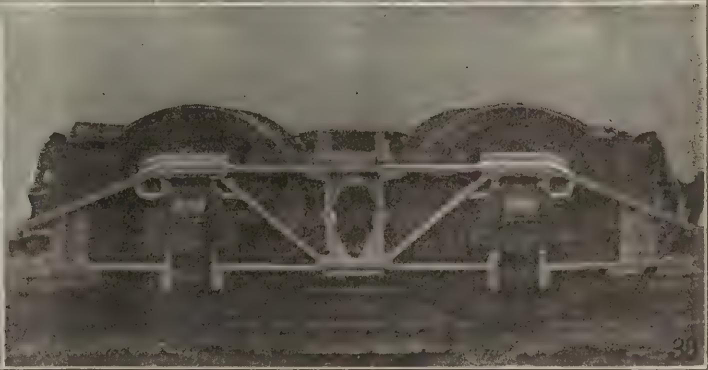
Not Classified

Air pump piston, built up
Bell cranks, fracture welded
Bushings, spot welded
Chafing iron, built up
Chafing iron, steel plate welded in
Draw bar yokes, built up
Drill press shafts, built up
Dynamo doors, fracture welded
Gasoline engine cylinder, fracture welded
Grease cups, welded to rods
Link latch blocks, built up
Motor car castings, fracture welded
Reverse lever, fracture welded
Reverse lever latch, built up
Running board brackets, extensions welded on
Throttle latch, built up









Electric Welding of Equipment on Foreign Roads

Fig. 33.—Journal Box Completely Built Up

Fig. 34.—Gear Casing Built Up

Figs. 35 and 36.—Wheels Cast in Separate Parts Assembled by Arc Welding Process

Figs. 37 and 38.—Truck Frame and Bolster Built Up by Arc Welding

The American Railroad Association committee on welding truck side frames, bolsters and arch bars, has recommended that welding of cracks or fractures should not be permitted on axles, arch bars, car wheels or tires, truck equalizers, spring or bolster hangers, brake wheels, coupler bodies or knuckles, knuckle pin, locks, lifters or on parts made of alloy steel or heat treated carbon steel. It is not surprising that these recommendations were made if the conclusion was based on the average results obtained on railroads throughout the country as was no doubt the case.

It is generally conceded that there is an extremely wide variation in the quality of welds, the strength ranging from almost nothing to values equal to that of the welded part. Considering the results that have been obtained with the small amount of attention that has been given to the factors which determined the quality of welds, such as the training of operators, quality and kind of material that goes into the weld and methods employed in performing the weld, etc. It would seem that any limitations that are placed on autogenous welding should be designed to encourage the development of the art. With no other process is so much expected from the efforts expended than from that of autogenous welding. Without any special guidance or training, welding operators on railroads are almost daily required to perform welds under practically impossible conditions, and from the results of these haphazard applications the value of the process is judged by the execution.

The repairing of broken or fractured cast iron cylinders are among some of the applications which have been condemned by many, and while all cast iron parts cannot as yet be advantageously welded many parts can. A very bad break in a cylinder of a 2-8-2 Mikado type locomotive prepared for metallic arc welding is shown in Fig. 31. The fracture is lined with ½ in. wrought iron studs spaced approximately 2½ in. apart. The weld was made in sections by the back step method, progressing in an upward direction. The completed weld is shown in Fig. 32. No preheating or annealing was employed; instead, the heat was kept as low as consistent with good welding by using a small ⅛ in. diameter mild steel electrode. In the past most welds of this kind were made with a bare electrode. It is now considered that better work can be done with a "coated" electrode, in which case the metal flows smooth and seams a better union with the cast iron. The cylinder referred to above has been in constant service since April, 1919. Many other welds of its kind have been in service without any trouble being experienced for two years or more.

It may be of interest to know how some of the other countries are progressing in the electric welding art. A few illustrations will give some indication. A journal box completely built up by the arc process is shown in Fig. 33. A gear casing of an electrically driven car, completely built up, is shown in Fig. 34. Gear wheels, which are cast in separate parts, as shown in Fig. 35, are then assembled together by arc welding, as shown in Fig. 36. A truck frame and bolster built by arc welding is shown in Figs. 37 and 38. This work was done by the New South Wales Government tramways at Sydney, Australia, which recently had a representative traveling through America, gathering information for the purpose of further extending the process of arc welding.

For the Man Who Wants to Know

Questions of general interest to electrical men addressed to the editor wil be answered each month in this column. Be sure to put your name and address in each letter otherwise it may not receive attention. The question, however, will be printed signed by the sender's initials only. Fictitious initials may be used is so desired.

Queries

1. Is the oil used on railroads and known as "signal oil" a satisfactory oil for filling the starting compensator tank of a 10-hp., 220-volt, 3-phase, 60-cycle motor? The motor always starts without load, but will blow a 75-ampere fuse and I believe it blows 90-ampere fuses at times; one of the compensator coils burned out after about two weeks' operation, but has been repaired and is again in service with the signal oil in the starting compensator.

2. Would you advise the use of what is known on the railroads as "black car oil" for filling the compensator tank for 10-hp. to 25-hp. motors, 220 or 440-volt, 2 or 3-phase, 25 or 60-cycles?

3. Which of the following would be the most satisfactory for use in the compensators, signal oil, black car oil or gas engine oil?

4. Does the placing of iron washers both under and over connections in an electrical circuit interfere most on a circuit of low voltage and high current or on a circuit of high voltage and low current? J. B.

Answers

1. No. The only kind of oil that should be used for compensator tanks is what is known as transformer oil. Transformer oil is a special grade of mineral oil which does not carbonize easily and has no injurious effect upon insulation.

2. No. If such a thing is possible "black car oil" is worse than "signal oil."

3. Gas engine oil is also entirely unsuited for use in compensator tanks.

4. Iron washers, if rusted, many increase the resistance of a circuit at a connecting point. A high voltage would easily break down this small resistance, but a low voltage circuit might be opened entirely by it.

Wireless Telephone Communication may soon be established between the passengers on board London-Paris aeroplanes and any telephone subscriber in London. This is to be made possible by a wireless station with a 1,500-mile range, installed on top of the new Air Ministry building, which is now nearing completion.

The number of Electric Furnaces for steel making in the United States at the beginning of 1920 was 323 and in Canada 40, compared with 287 and 43, respectively, a year ago. It is estimated that the total number of electric furnaces in the world at the opening of the current year was 875, compared with 815 in 1919 and 140 in the middle of 1912.

World output of electric steel in 1918 was 1,155,273 tons, of which the United States produced 511,364 tons, Germany 221,824 tons and Great Britain 147,922 tons. Canada was fourth, with an estimated output of 120,000 tons. Other countries producing electric steel were Austria-Hungary, France, Italy and Sweden. In 1913 the world production of electric steel was 182,433 tons, of which Germany produced 101,755 tons.

Sweden and Italy are the leading producers of electrically-made pig iron. Their output was approximately 120,000 tons in 1917.

Direct Current Power For Electrification

One Method of Reducing the Drop in Grounded Return Rails and Advantages Gained Thereby

By Alfred Raworth
Electrical Engineer, South Eastern & Chatham, England

IT is, possibly, useful to consider at the present time, when railway electrification on a large scale appears to be imminent, the engineering methods that will be adopted, and particularly those which will be used in transmitting electrical energy between the substations and the trains.

The problem consists in delivering, over considerable distances, large blocks of power to trains in motion, and the difficulty of solution arises from the fact that, while a comparatively high pressure is necessary for the attainment of economical transmission, a comparatively low pressure is desirable for satisfactory operation of railway motors and their control apparatus.

Early examples of railway electrification embodied the use of direct current at 600 volts, a pressure admirable for the operation of electric train equipments but much too low for economical transmission, and involving a very close spacing of substations in order to keep the drop of pressure within reasonable limits.

Recognition of this fact has led to the pressure being increased up to 1,500 volts for use on motor car trains, but, while this pressure has been proved to be eminently suitable for the satisfactory operation of electric train equipments and not so high as to prohibit the use of conductor rails, it is still too low for the attainment of economical transmission in the case of long distance main lines carrying heavy traffic.

In order to overcome the disadvantages and expense of transmission at such low pressures, and to endeavor to render the direct current motor available for application to long distance main line railways, the pressure has been raised to 3,000 volts in the case of one railway now in operation in America and utilizing electric locomotives.

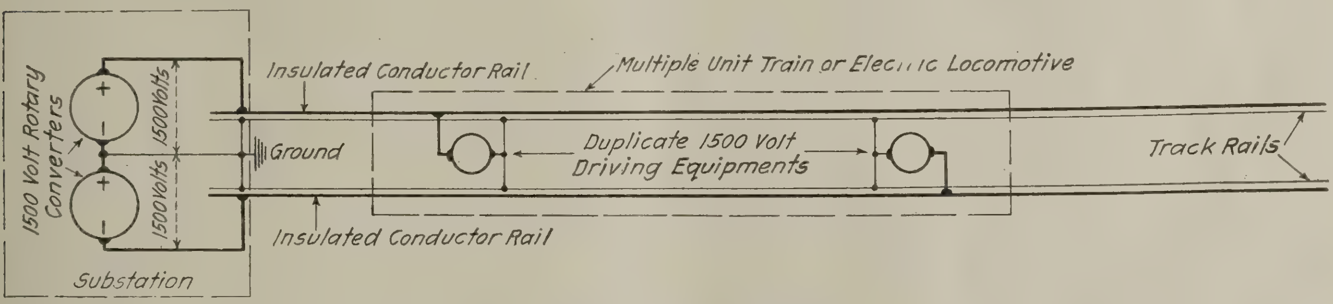
While it may be possible that the greater clearances and complications in control apparatus inseparable from the use of this pressure may be tolerated in an electric locomotive, it is quite certain that a pressure of 3,000 volts is too high for use on motor car trains.

Realization of these considerations is doubtless responsible for the recent suggestions of F. W. Carter* and Roger T. Smith† that it may be necessary, in connection with the electrification of our main line railways, to install two separate track conductor circuits, a low voltage conductor rail for the operation of suburban motor car trains, and an overhead wire for supplying current at high voltage to electric locomotives working long distance trains.

It must surely be admitted, however, that such an arrangement, resulting in increased cost of construction and reduced load factor on track conductors and substation apparatus would be, at best, only a makeshift, and inferior in every respect to a single system capable of handling, with equal efficiency and convenience, both classes of traffic.

Inseparably bound up with the problem of transmission between the substations and the trains, is the question of the measures to be taken to guard against the possibility of damage to other persons' property which may result from current leaking from grounded return conductors.

In certain cases, the tramway practice of using the running rails as a grounded return conductor has been followed, and in places where the drop of pressure in such grounded returns is more or less immaterial, this method may be justifiable; but, in thickly populated areas, such as those through which most British railways run and in which gas and water pipes, electric cables, apparatus and circuits liable to damage from stray currents abound, it is most certainly dangerous.


1500 Volt Rotary Converters
+
-
+
-
1500 Volts
1500 Volts
Insulated Conductor Rail
Multiple Unit Train or Elec ic Locomotive
Ground
Duplicate 1500 Volt Driving Equipments
Track Rails
Insulated Conductor Rail
Substation

Circuit Diagram for Proposed System

Some of the railways in England that have carried out electrification schemes have proceeded under Section 86 of the Railway Clauses Consolidation Act, 1845, which provides that it shall be lawful to use and employ locomotive engines or other moving power, while other companies, usually owing to the necessity of raising additional capital or of compulsorily acquiring land, have obtained special parliamentary powers.

---

*Electric Review, July 18, 1919, p. 69.

†Presidential Address to Institution of Electrical Engineers, November, 1919.

Railway companies which have proceeded under the Railway Clauses Consolidation Act, 1845, are under no obligation to observe any regulations regarding the use of grounded return conductors, but they are, of course, liable to be proceeded against as a result of any damage which they may cause by the use of such grounded returns.

On the other hand, railways which have applied for special powers have, in some cases, been compelled to comply with the Board of Trade regulation applicable to tramways, which limits to seven volts the permissible drop in grounded returns, and there has always been inserted in their Acts the following provision:

> When any department of His Majesty's Government represents to the Board of Trade that the use of electrical power under this act injuriously affects or is likely to injuriously affect any instruments or apparatus whether electrical or not used in any observatory or laboratory belonging to or under the control of that department, the Board of Trade, after such inspection or inquiry as they may think proper, may by their regulations require the company to use such reasonable and proper precautions including insulated returns as the Board of Trade may deem necessary for the prevention of such injurious affection.

The clause quoted, usually referred to as the "Observatory Clause," places upon the railway the obligation of avoiding any chance of interference with scientific instruments installed in observatories and laboratories with the ever-present possibility that, in the event of such damage occurring, the railway may be required to install insulated returns.

It will be observed, therefore, that, in any case, it is necessary for a railway company, if they use the running rails as a grounded return, to provide that the drop in pressure shall be kept down to a very low value.

The difficulty of so doing will be appreciated, when it is stated that the resistance of a pair of running rails is approximately .03 ohms per mile, and the current required at starting by an electric locomotive of a type suitable for working express passenger trains, or by a nine coach train suitable for suburban services on main line railways, is about 3,600 amperes at 600 volts.

If we assume the condition in which two such trains are starting, opposite one another, one on each line of a railway with two lines of way, and midway between adjacent substations, so that half of the current required by each train is supplied by each substation, the drop in volts in a grounded running rail return would be, per mile length of section between substations:

At 600 volts	27.
1,200 volts	13.5
2,400 volts	6.75
3,000 volts	5.4

If it is decided to limit to, say, 27 volts, the drop in the grounded return, we find that the maximum distances between substations, for the conditions assumed will be:

At 600 volts	1 mile
1,200 volts	2 miles
2,400 volts	4 miles
3,000 volts	5 miles

These distances may be increased in proportion to any increase in the negative drop which it is decided to allow, but it is important to remember that the condition of two trains starting in the middle of a section corresponds to the heaviest condition likely to arise, only in the case of very short sections. On a section of greater length, on lines over which a frequent service is operated, it will be possible that more trains may be in the section at one time, drawing a larger total current and necessitating a reduction in the distance between substations.

It will be obvious that this very close spacing of substations will produce a very bad substation load factor, resulting in high first cost and operating expenses, and will make such an arrangement, even with a pressure as high as 3,000 volts uneconomical for the equipment of long distance lines which are required to handle heavy traffic.

Some railways have endeavored to reduce the pressure drop in grounded returns by laying additional rails or feeders connected in parallel with the running rails, but this method, while failing to give the same security as an insulated return, may be, as in some cases in America in which a multiplicity of negative feeders are employed, even more expensive.

The installation of an insulated return conductor carries with it great advantages, in that it enables the permissible drop in the transmission system between the substations and the trains to be determined economically, and gives complete security against the dangers incidental to a grounded return; on the other hand, as usually installed, it possesses certain disadvantages in connection with the maintenance of insulation and the location and clearance of faults to ground.

Having enumerated the difficulties of the problem of transmission between the substations and the trains in connection with long distance lines which are required to handle the heaviest traffic, it is proposed to suggest a method by which they may be overcome, that is to say, by which:

1. Direct current may be economically and efficiently produced in the substations and delivered to the trains at a voltage low enough to enable multiple unit equipment to be operated safely and satisfactorily.
2. Direct current may be transmitted at a potential from ground low enough to permit of the use of a conductor rail.
3. The voltage of transmission may be high enough to secure the maximum economy.
4. All danger of causing damage to other persons' property by electrolysis or leakage currents may be avoided.
5. The difficulties in connection with the use of an insulated return, as usually installed, may be eliminated.

The arrangement proposed is shown in the diagram and embodies the installation along each track of two insulated and protected conductor rails, connected as the outers of a three-wire system, of which the running rails, bonded and cross bonded, would form a grounded neutral conductor.

Each conductor rail is at a potential of 1,500 volts, the one above, the other below the ground.

Each motor car train unit and each locomotive, in accordance with usual modern practice, carries two duplicate equipment, designed to operate at 1,500 volts, and the arrangement is such that each side of the system supplies the current for half of every train.

By these means, the system is quite perfectly balanced, and the running rails forming the neutral conductor will not normally carry current.

The only occasion upon which any current will be carried by the running rails will be when the collector shoe of a train is crossing a gap in a conductor rail, necessitated by special work in the permanent way, but in such a case, the current will only be that required by one two-motor equipment, and it will flow only momentarily.

The arrangement, while securing the advantages of transmission at 3,000 volts through conductor rails of large sectional area, does not require any direct current machine, switchgear, train equipment, conductor rail, or other apparatus to work at a potential of more than 1,500 volts from ground.

Upon lines carrying the heaviest class of traffic, substations may be economically placed some 30 miles apart. They will, consequently, supply a large number of trains and will have the advantage of a good load factor.

The necessary conversion plant, instead of being distributed in small units in a large number of substations, each of which would of necessity contain a spare machine, will be concentrated in large units in fewer substations, thus reducing both the capital cost of the plant required and the substation operating expenses.

Estimates which have been prepared in connecton with both suburban and main line electrification show that, when compared with other arrangements, the methods now proposed will result in lower first cost and lower operating expenses.

The Voltage of the Electric Welding Arc

By C. J. Holslag.

After careful compilation of about five hundred voltage redaings across the arc as well as of the current through it, I was forced to the conclusion that the current does not affect the voltage enough to influence an ordinary meter. With an oscillagraph the rapid variations in voltage due to changes in the current can be traced; but the voltage as shown by an ordinary meter, no matter how delicate, is constant for any set of given conditions. The conditions which do change the voltage across the arc are: first, length of arc; second, type of electrode and gases in the arc such as would appear from coatings on the electrode or flux used on the job.

There is a voltage below which an arc cannot be held, and regardless as to whether this is a counter e. m. f., a *CR* drop, or a combination of the two, we will call it the minimum necessary arc voltage. This lies between 10 and 11 volts. There is always added to the minimum voltage a constant drop, depending on one of the three conditions named above, and this drop varies from 1 or 2 volts in bare wire at ordinary welding currents, to from 15 to 20 volts for heavily coated wires. There is the added result, due to the average value of the superimposed guardian or puncture voltages, the peaks of which are shown only on the oscillagraph. The average value, of course, adds to the other two, making the voltage across the arc, as we have found it to be, as follows: For bare wire from 11 or 12 volts to 22 volts, the lower value being the performance of a superhumanly steady operator holding the closest arc possible with a wire that has no carbon content nor any covering or flux. At the other end of the scale is the carbon arc, about which much has been published, with voltage varying from 40 to 55. The highest metallic arc voltage is that of very heavily coated electrode, such as the English quasi arc. The voltage across this varies from 27 to 40. The voltage across the arc of a completely coated gaseous fluxed electrode is from 22 to 35. The voltage across a half-coated electrode varies from 15 to 30, the variations being as before stated, the sum of the variable length voltage, the constant gas, ordinary resistance drop and the necessary voltage. The only voltage that is variable is that due to the man's hand in holding different lengths of arc.

I think it is admitted by now that the short arc is desirable; in fact, a short arc is absolutely necessary for good work. With a short arc there is less chance of the metal being oxidized, less chance that it will fall on cold work, less chance that nitrogen will be raised to such a temperature that it will combine with carbon and steel to form harmful compounds; and a point that has probably not been mentioned before, the total heat with a short arc is kept within reasonable control; namely, every welder knows that with a short arc he has the metal under control, but with a long arc the heat is raised by the voltage having risen across it, provided there is no decrease in the current and hence the temperature rises until the steel is "wild." And, whereas, the transition from a short arc to a long arc is easy, the transition backwards is very hard and the tendency is, once having started the long arc, to hold it at least until the end of the electrode. Unfortunately, when no check is made on the quality of the metal deposited, the long arc being easier held and depositing the metal faster it is liable to be used, and in some rare cases, such filling in castings, where the mass of metal is great enough to satisfactorily dispose of the increased rate of heat, it can be used to advantage.

There has been much promotion of constant current apparatus, and equal promotion of constant voltage, but it can hardly be denied that a constant rate of heat is what is desired and constant watts mean constant rate of heat. For a necessary change in length of arc due to various physical imperfections in the circuit or the electrode, this change being within the working range between too long an arc and too short an arc, there is considerable variation allowable—we would say ⅛-inch to 3/16-inch. Anything over 3/16 of an inch begins to be too long an arc, and rapidly tends to become ⅜-inch or ½-inch long, in which case no welding can be done. The metal of the electrode melts so much more rapidly than the work that there is not crater enough in the work to receive the electrode metal, and, unless the crater in the work is as large or larger than the deposited electrode metal, no welding can result. For instance, steel cannot be welded by pouring molten steel on it at any temperature except molten. The first lesson of the Electric Arc Cutting & Welding Company's school at Newark, illustrates this.

The conditions then for good welding are, first, control of the arc length; second, constant rate of heat; third, a good operator, because, with the first two named conditions ideally realized, we are still at the mercy of the man that guides the arc to weave the desired joint together.

The third condition of good welding: namely, the operator, results from training and experience. Some users of welding have all sorts of work and can train their operators on the easy, unimportant jobs first, gradually working up to the more careful jobs. Ship yards, railroads and job shops are shops of this class.

However, in industrial commercial work such training cannot be realized, and the operators must be "expert" when they start—at least on the job they are expected to do. For this either a certain amount of work must be spoiled in learning, which is generally not allowable, or the operator must be trained. One arc welding company realizes the necessity of operators and offers the following solution—to all customers the offer is made of training their men free at the welding training school they maintain. To any one desiring to learn welding, other than customers, a nominal fee is charged. At this school the operator is taught as much as he desires to learn. In connection with the school a large commercial welding business is carried on, so that all angles of practical work are gone into, with theoretical training, and thereby the operator will have the foundation to meet any job which would, otherwise, be new to his experience.

In limiting the voltage across the arc some kinds of apparatus have been equipped with relays which cut the arc out or cut the resistance in, or give other notification that the arc is too long. Other efforts to limit the voltage of the arc have been made by reducing the open circuit voltage or guardian voltage until only a certain length arc could be held. It is interesting to note here that an arc cannot be held with the supply voltage across it, in fact, the values begin to be twice the voltage of the arc before any arc at all can be held. This is true of alternating current or direct current. The minimum voltage at which an arc can be held is around 31 or 32 volts and this is obtained with bare wire with no flux or coating. While the gases of coated wires help to hold the arc, they also raise the necessary voltage and, hence raise or hold about the same minimum voltage at which an arc can be held. An arc can be held on alternating current with just as low an open circuit voltage as on a direct current. With alternating current the guardian voltage is supplied partially by inductive kicks or transformer characteristics, and the normal open circuit voltage can be lessened. On direct current a reactance gives a similar action, but in much less degree, the average voltage across the arc showing the effect of these two, but the open circuit voltage, at least the quiet open circuit voltage, does not show it. The only method so far discovered of limiting the length of the arc without moving parts, and without losing the necessary open circuit or guardian voltages for puncturing through dirt, oil, slag and giving good penetration is by the alternating current special transformer for arc welding. This apparatus also gives constant rate of heat automatically and unchangeably—again without any moving parts. No apparatus with moving parts will stay operative and adjusted indefinitely. Moving parts spell "maintenance," and maintenance is labor, the crying problem of the age.

SYNOPSIS OF VOLTAGE ACROSS ARC.*

Condition	Bare Wire	Half Coated	Full Coated	Heavily Coated
Close Arc (overhead work)....	11 to 15	15 to 22	23 to 25	27 to 32
Medium Close (good arc)....	13 to 18	20 to 25	24 to 28	30 to 35
Medium Long (poor arc)....	17 to 20	23 to 27	27 to 32	33 to 38
Long Arc	20 to 25	26 to 30	30 to 35	36 to 40

*From compilation of many readings.

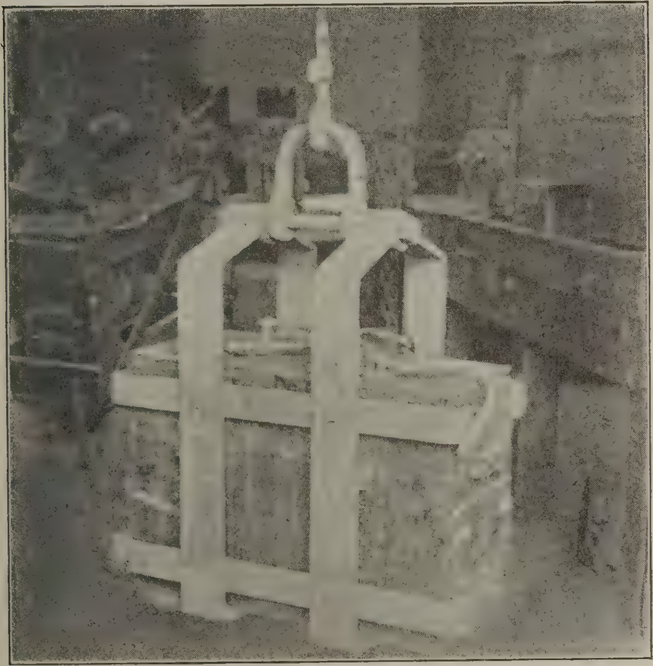
* * *

The Gare du Nord in Paris

PRACTICAL STUNTS

Battery Transferring Device

Two lead tanks of a car lighting battery fully equipped with plates is too heavy a proposition for one man to handle alone unless he has some device to assist him. The care of batteries is such that it can best be given by moving them about from one part of the shop to the other so that various kinds of work can be performed upon them during their journey through the shop. Since most of these tasks are one-man jobs it proves very convenient to have it so arranged that one man can move the batteries from point to point, and this problem has been very cleverly solved at the Morris Park Shops of the Long Island Railroad, by means of the device shown in the illustration.

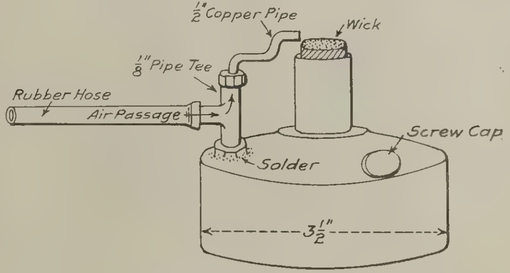


Cradle of Strap Iron for Transferring Tanks

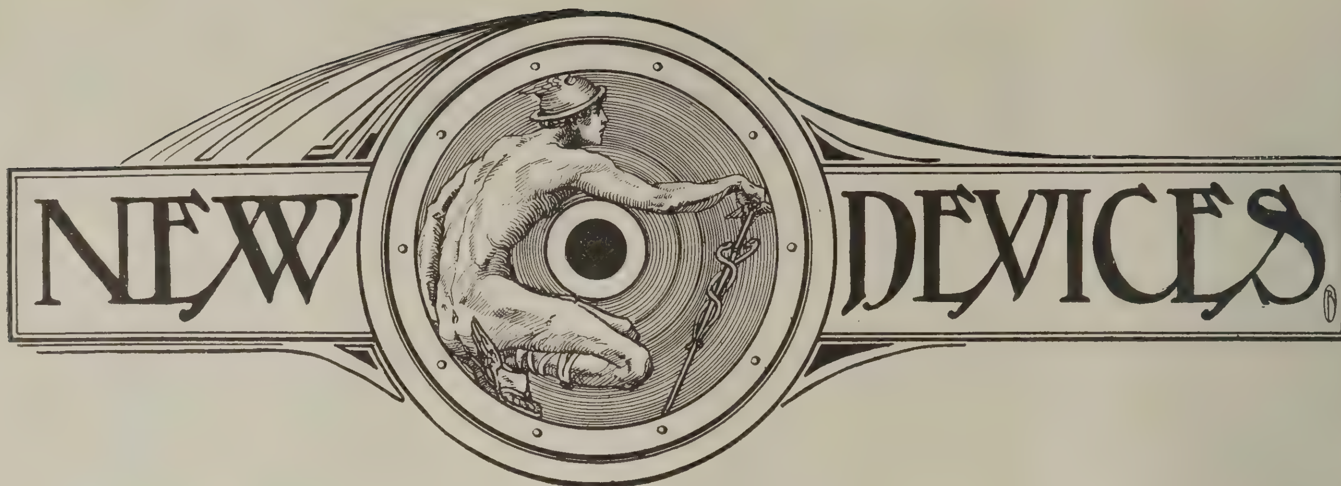
The arrangement for lifting the tray with two tanks in it consists of a winged frame-work of heavy iron. The vertical iron straps are about one-half inch thick by three inches wide. These are bolted to two similar pieces but of slightly lighter material which extend in a horizontal direction along the side of the tray and are turned at the ends around the corners of the tray for about two inches. The vertical irons are also turned under at the bottom for about the same distance. There are two sides constructed in this manner which are hinged at the top by means of a bolt. This bolt also passes through the two eyes of a U-shaped hanger to which is attached the hook of a chain hoist. When there is nothing between the two frames the balance is such that they tend to come together at the bottom, and when once the tray with its heavy contents is placed within the frames there is practically no danger of their opening outward and dropping the load. The chain hoist is attached to a wheel which travels along a track that connects every part of the shop and hence it is a simple matter for one man to move the cells to any point in the shop he desires.

A Home Made Blow Torch

There are times when a soldering iron or the ordinary gasoline blow torch are not suited to the work to be done. For joining very small parts and small electric wires, the soldering iron is too clumsy and the gasoline torch gives much more heat than is needed. The requirements of such cases may be often met with a small alcohol torch that will produce a very hot pin point blaze when a blast of air is blown across the wick of the torch. Such torches can be purchased but it is a very easy matter to make one that is every bit as good. The illustration shows such a torch made from an old tin reservoir of an oil lamp. Almost any tin container will answer the purpose. The sketch shows the construction so clearly that further description is not needed. Such torches are usually mouth blown but there is no reason why they could not be attached to an air supply pipe at a workbench where a lot of small soldering could be brought to the torch.



A Simply Constructed Blow Torch

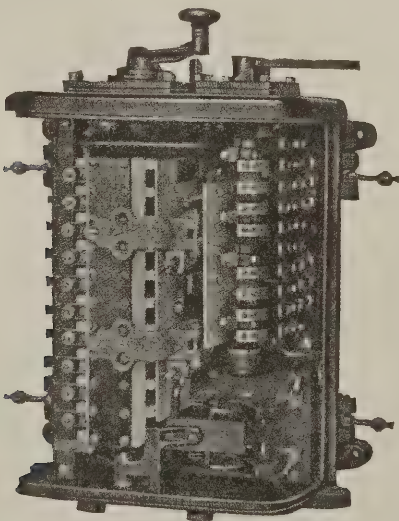


NEW DEVICES

New Drum Controller for Series Parallel Operation of Locomotive Motors

A drum type controller for series-parallel control of two-series motors is one of the new products of The Cutler-Hammer Manufacturing Company, of Milwaukee, Wis. This control, which is provided with both a main cylinder and a reverse cylinder, is for use on storage battery locomotives or on trolley locomotives using 250 volts or less.

The motors are accelerated by the main cylinder, which has seven points of control. A star wheel provides an interrupted motion to the lever, so the operator readily feels the speed points. The fourth point is the full series or low speed running point and the seventh the full parallel or high speed running point. All intermediate points are resistance points. The Wheatstone bridge method is used for transition from motors in series to motors in parallel between the fourth and fifth points of control, and as the circuit is not opened, continuous torque is obtained during the transition. Arc barriers are provided between each contact finger, and strong magnetic blowouts prevent excessive arcing.



Showing Controller With Case Removed

The reverse cylinder is positively interlocked with the main cylinder, so it cannot be operated when the latter is in any but the "off" position. The fingers of the reverse cylinder are therefore not used for making or breaking the current; hence the contact parts will last indefinitely, and magnetic blowouts are unnecessary.

Two cutout switches allow either motor to be bypassed, if it becomes damaged in any way, and the locomotive operated by the other motor until repairs are made. When one cutout switch is thrown to bypass its corresponding motor, mechanical interlocks prevent closing the other cutout switch or operating the main cylinder beyond its full series position, thus eliminating the possibility of a short circuit.

A dust-tight and weatherproof construction is obtained by fitting the sheet metal cover under a ledge in the top and providing a rubber gasket between the edges of the cover and the cast iron frame.

This new controller has the following features of construction common to other C-H Drum Controllers: cast iron sections of cylinders clamped on square insulated shaft, using no keys or taper pins, thus making removal easy; cylinders readily removed from case by merely taking off top plates; steel contact fingers of main cylinder mounted on square insulated metal shaft, which can be removed by taking out two cap screws; all fingers provided with drop forged copper tips of the non-stubbing type.

The contact fingers and segments may be adjusted or renewed without removing the cylinders from the drum case. Those on the reverse cylinder are readily accessible, while those on the main cylinder are exposed by merely loosening two thumb nuts and throwing back the blowout plate and arc barriers.

Most mine duty apparatus is employed where the service conditions are severe and delays in operation costly; consequently this new controller has its parts very liberally proportioned to prevent wear and breakage, and those parts which do wear are made accessible and easily renewable.

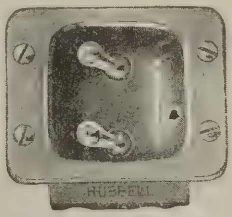
Two New Connector Fittings

Harvey Hubbell, Inc., Bridgeport, Conn., have recently added two new devices to their line of electrical specialties, viz.: No. 6180 cord connector and No. 6337 elongated cap. The former measures only 1⅝ in. over all. Although small, it is sturdy enough for use with any appliance where a cord connector of 660W-250V capacity is desired.

The No. 6337 elongated cap is made of composition throughout. While similar in appearance to their No. 6336 cap, this has a half-inch cord hole for No. 14 and 16 reinforced cord.

The New Cord Fittings

Another new product of this company is a new type of two-gang switch for automobile use generally, but perhaps more especially adopted for closed car interiors. It is in the popular toggle pattern and so designed that the handles are countersunk in gracefully curved recesses which add materially to its artistic appearance. The new type will be listed as the No. 8022 switch.



The New No. 8022 Switch

A New Turbo-Generator

The Pyle-National Company, Chicago, has placed on the market a new Turbo-Generator, Type M, 3 to 10 kw., which can be used for any class of train lighting service, such as suburban, or where such service comes within the capacity of the generator. This machine is a self-contained unit and the turbine is of the impulse type with an enclosed governor in the turbine casing. The governor is mounted as a unit upon the wheel retaining nut and can be removed readily for inspection or for the purpose of cleaning the shaft and the interior of the sleeve. The removal and replacing of the governor can be made without changing the governor setting.

On each end of the governor spring is a steel ring, one has a concave surface, the other a convex. These engage with corresponding surfaces on the governor yoke which permits a self-alining action between the several parts and eliminates entirely the tendency to cramp the sleeve on the shaft causing a retarded governor action. The end of the governor sleeve is hardened and highly polished where it comes in contact with the carbon plug, this plug corresponding to the anti-friction ring in other machines. The valve motion is transmitted from the governor to the valve through the governor arm. The valve adjustment is made by turning the governor adjusting plug and without removing the valve cage. The governor valve is placed in the turbine cover, making it readily accessible. A speed regulation of 2 per cent is obtained between no load and full load.

A labyrinth packing is employed to seal the opening around the shaft. The rotating element of this packing forms a tortuous path for the steam to escape causing it to condense, thus making a water seal. The following is a general specification of this Type M turbo-generator:

Capacity—3 to 10 kw.

Voltage—32 to 220 (3 kw.) 64 to 220 (5 kw.).

Permissible overload, 30 per cent (a machine should not be recommended for a continuous load 30 per cent above its rating); this reserve power should be for emergency use only.

3 to 5 kw. Net weight—500 lb.

Length over all—39 in.

Height (maximum)—18⅞ in.

Width (maximum)—20⅝ in.

The shaft of this machine is made of a high carbon steel and is mounted upon large ball bearings. The wheel and governor are overhung, but the ball bearing carrying the turbine end and the shaft are of such proportion that there is no possibility of vibration or undue wear upon the bearings. The turbine ball bearing is mounted upon a sleeve providing a large wearing surface on the shaft and is positively driven by lugs cast upon the armature fans which engage with corresponding lugs on the sleeve. The generator bearing is held upon the shaft by a nut. All bearings are liberally supplied with oil and oil cellars are of sufficient capacity to lubricate the bearings for several months, as is indicated by a service test when this machine, in actual operation daily for four months, ran without adding oil. However, 30-day oiling periods are recommended.

The generator is of the bi-polar type, compound wound, with laminated pole pieces and a cast steel yoke. The armature is drum wound, with the core mounted directly upon the shaft. The commutator is a new patented structure, having a third internal retaining ring, thus eliminating outside banding.

The brush holders are mounted upon a ring which permits them to be moved in either direction for adjustment or to be brought above the commutator for the purpose of surfacing the brushes. The binding posts are brought through the generator yoke to the outside of the machine, making the connection of the lead wires a simple matter.

It is claimed the voltage of this machine is constant regardless of atmospheric temperature; in other words, the machine will run and generate the same voltage in both extremely hot summer weather or in extremely cold weather.

The machine has a three-point suspension or base, thus avoiding any tendency to cramp or spring the frame by bolting to an uneven foundation. It is claimed no sparking whatever is detected at the brushes and the operating temperatures are exceptionally low.

Pipe End Fitting with Bushing

A new line of pipe fittings and bushings is being manufactured by the Adapti Company, Cleveland, Ohio. The bushings have standard pipe threads and are made of composition material which the maker states is of exceptional mechanical and dielectric strength.

General News Section

The Standard Underground Cable Company announces the removal of its St. Louis sales office, in charge of E. J. Pietzcker, from the Security building, where it has been located since 1897, to the Arcade building.

Advances to Railroads by the War Finance Corporation have amounted to $204,794,520; and of this $134,436,310 has been repaid up to November 15, according to the annual report of the Secretary of the Treasury; leaving a balance of $70,358,210 outstanding.

Commutation Tickets on the Pennsylvania Railroad for certain long distance journeys must bear the photograph of the holder. This rule went into effect on December 5 and, according to an announcement of the company, is made necessary because of frequent misuse of tickets between Philadelphia and Trenton (31 miles) and between Trenton and New York (58 miles).

The Western Electric Company announces that its steampship and steam railroad business will be handled by the following men: **E. R. Morgan** at the Western Electric Company's Boston house will have charge of the New England territory; **William Lancaster** at the Richmond house will handle the territory which includes Virginia and North Carolina; and **R. D. Eves** at Cincinnati, the territory including Kentucky, Tennessee, southern Indiana, southern Ohio and the western part of West Virginia.

Major General Squires of the United States Army Signal Corps has authorized tests of his wired wireless on the New York Central between New York and Albany. By the use of this modified wireless scheme the signal corps believes it entirely practicable to telephone from the locomotive of a 100-car train to the caboose at the end, as well as to telephone to fixed stations along the road. If these tests prove successful, there is every reason to believe that development work will be brought to a conclusion within the next few months.

The Committee of Engineering Council on curricula of engineering schools has reported with reference to a suggestion that the engineering course in the colleges be extended to six years, that it does not favor the substitution of a six-year course for the present four-year course generally in the engineering colleges of the United States, although it calls attention to the fact that the longer course is now offered at a number of colleges. The committee strongly urges the extension of facilities for vocational training throughout the United States and particularly in the industrial centers.

On December 10th the Norma Company of America, manufacturers of "Norma" Precision Bearings, moved its factory from the Bronx, New York City, to Anable avenue, Long Island City, N. Y., where a modern four-story reinforced concrete building has been acquired. The new plant is being rapidly equipped with the special machines needed for precision manufacture, and the full capacity will be available shortly. The executive offices at 1790 Broadway have been consolidated with the factory at the new address.

Daylight Saving and the advantages of the plan are now under discussion in 16 states, according to Marcus M. Marks, of New York City, who says that public sentiment is being crystallized so that these 16 states will be ready by next spring to follow the aldermen of New York City in the adoption of a law to set the clocks forward in 1920 the same as was done in 1919 under the new obsolete federal statute. Mr. Marks thinks that there will be a general movement next year to begin the use of "summer time" a month later than heretofore, and to terminate its use a month earlier.

Proposed Electrification of Italian Railways

The London Times Trade Supplement reports that the Council of Ministers has approved a scheme, proposed by the Transport Minister, De Vito, for the electrification of the State railways. The bill provides for the exploitation of the national water power resources and their utilization for propulsion. The first program, which limited the improvement to 2,000 kilometers, is now extended to 6,000 kilometers. This includes the two principal trunk lines across the Apennines, viz., the two "Direttissime," Genoa-Tortone and Bologna-Florence, eight mountain passes and the principal arteries of the railway system of the peninsula from Trient to Reggio, Calabria, or from Turin to Trieste. The bill provides for an expenditure of 800,000,000 lire spread over eight years. Other sums are provided for the requisition of material and for the government's subsidies to the new plants. The bill will be submitted to the King shortly. The Trentino alone can provide at least 1,000,000 horsepower, while the mountain basins of numerous rivers and torrents along the Alps and the Apennines can be transformed into artificial lakes.

Electrification of the North Eastern Railway

The directors of North Eastern Railway, England, have previously sanctioned a scheme for the electrification of the main line between York and Newcastle (a distance of 80 miles). The scheme provides also for the electrification of the loop line (31 miles in length) from Northallerton to Ferryhill via Stockton. On these portions of the railway there is a very heavy and varied traffic, ranging from East Coast and other important through trains to local freights. Hitherto the experience of the company with electric traction has been confined to the working of a dense local passenger traffic on Tyneside, between Newcastle, North Shields, Tynemouth and Whitley Bay, and of the coal traffic between Shildon and Newport (Middlesbrough). No other company in Great Britain has, however, experimented with the electric haulage of freight trains.

On Tyneside the third rail system is in use, but between Shildon and Newport overhead electrical equipment has been adopted. The new proposal is a combination of the third rail and overhead systems, and the general idea is that the former should be used on the running lines, and the latter adopted in the freight yards and at large stations.

PERSONALS

E. L. Kilburn

Edward D. Kilburn, who since March 16, 1917, has been New York district manager of the Westinghouse Electric & Manufacturing Company, was recently elected vice president and general manager of the Westinghouse Electric International Company, New York, which was formed in the spring of 1919 to succeed the Westinghouse Electric Export Company. It handles the Westinghouse foreign business and is world-wide in its scope, exclusive of the United States and Canada. Mr. Kilburn was graduated from Cornell University, and immediately after leaving college he entered the employ of the Westinghouse Electric & Manufacturing Company, for a number of years being located at the Syracuse office of the company. Subsequently he was transferred to the Westinghouse Machine Company with headquarters at New Haven, Conn. In 1915 he returned to the Electric company as manager of the power division of the New York office. A year later he was also made manager of the railway and lighting divisions, subsequently becoming manager of the office. **Maurice Coster,** who has been actively engaged for more than 30 years in handling the foreign interest of the Westinghouse Company continues as vice-president of the International Company with advisory duties. The president of the International Company, **Loyall A. Osborne,** who is senior vice-president of the Electric company, was actively engaged in national work during the war, having been chairman of the executive committee of the National Industrial Conference Board, chairman of the committee of the Council of National Defense, a member of the National War Labor Board, and other important bodies.

J. H. Deppeler, chief engineer of the Metal & Thermit Corporation, New York, has been elected a vice president of the American Welding Society. **P. F. Willis,** president of the Henderson-Willis Welding & Cutting Company, has been elected a director of the Society.

John Brogan, electrical repairman of the Chicago East district of the Pullman Car Lines, at Chicago, has been appointed to the position of foreman electrician's assistant with that company, with headquarters at Jacksonville, Fla. This position has been created on account of the heavy winter business in the Jacksonville district.

I. F. Baker

I. F. Baker of the Westinghouse Electric International Company, who has been located in the New York office of that company for the past two years, is now on his way to Tokio, Japan, where he will act as a special representative of the Westinghouse International Company.

Mr. Baker entered the graduate student course about 1908, later serving in various capacities in the resale and contract sections of the sales department. In 1913 he was transferred to the foreign department which later became the Westinghouse Electric International Company.

Mr. Baker has many friends in the Electric company as well as in the International Company and will carry with him their best wishes for success in his new field.

W. L. R. Emmet

W. L. R. Emmet, consulting engineer at the General Electric Company, Schenectady, N. Y., has been awarded the Edison medal for 1919, for inventions and developments of electrical apparatus and prime movers. The Edison medal was founded by the Edison Medal Association, composed of associates and friends of Thomas A. Edison. It is awarded annually by a committee of twenty-four members of the American Institute of Electrical Engineers, and is among the highest honors of the electrical profession. Mr. Emmet was born in Pelham, N. Y., July 10, 1859. For many years he was consulting engineer of the General Electric Company, where he designed the electric propulsion machinery for the battleship "New Mexico," the first warship of any nation to be driven electrically. Mr. Emmet's important inventions include several types of transformers and oil switches. He is a member of the American Philosophical Society, American Institute of Electrical Engineers, American Society of Mechanical Engineers, Society of Naval Architects & Marine Engineers, Engineers' Club, the University Club of New York and a member of the Naval Consulting Board of the United States.

Robert L. Sullens, electrician, first class, on the St. Louis-San Francisco Railroad, has been appointed electrician, first class, on the St. Louis, San Francisco & Texas with headquarters at Fort Worth, Texas, and **Grafton H. Sillman** has been appointed electrician, first class, on the same road with office located at Sherman, Texas.

Major J. L. Hays has been appointed electrical engineer of the Stone Franklin Company at New York City. Major Hays brings to his new position wide experience in electrical engineering problems, particularly as regards electrical car lighting. Major Hays was graduated from Lehigh University in 1909, with the degree of Electrical Engineer. Upon graduation he joined the electrical department staff of the Baltimore & Ohio Railroad and worked successively as mechanic, draftsman, inspector, general foreman and assistant engineer. From the Baltimore & Ohio Railroad he went with the Seaboard Air Line as electrical engineer and when war was declared with Germany he was commissioned as major in the Quartermaster's Corps and was the officer in charge of the Electrical Section of the Engineering Branch, responsible for electrical construction for the army in the United States. At the conclusion of the war he joined the Stone Franklin Company.

J. L. Hays

Arthur Elliot Allen has been appointed district manager at New York for the Westinghouse Electric & Manufacturing Company to succeed **Edward D. Kilburn**. Mr. Allen is a native of Toronto, Canada, and was educated in both England and this country. In June, 1902, he entered the employ of the Westinghouse Electric & Manufacturing Company at its Newark works, subsequently being placed in charge of the test department where he remained until 1910. In that year Mr. Allen was loaned by the management of the company to the International Electric Protection Company, for which company he acted as chief engineer. In 1911 Mr. Allen, having completed that temporary work, returned to the employ of the Westinghouse company, being assigned to the supply division of the New York sales office. On December 1, 1915, Mr. Allen was appointed manager of the supply division of the New York office, which position he retained until he answered the call of his country and joined the Canadian Overseas Forces as a private in October, 1917. Later he was sent to the Canadian Officers' Training Camp, was commissioned a second lieutenant in the Royal Flying Corps, and went overseas as a technical officer.

A. E. Allen

Overseas, Lieutenant Allen was stationed in England at the Salisbury Plains School for Navigation and Bomb-dropping. This school was by far the largest one operated by the Royal Air Forces and Lieutenant Allen was charged with the maintenance of all its engines and planes. In September, 1918, he was attached to the "Bombing Berlin" squadron as a technical officer. This was the squadron which was detailed to drop bombs on Berlin in retaliation for the bombing of English towns. The signing of the armistice, however, ended the war before this squadron arrived at the front.

After being honorably discharged from the army Mr. Allen returned to the New York office of the Westinghouse company as executive assistant to the manager, from which position he was promoted to manager, as stated.

TRADE PUBLICATIONS

Mechanical Memory Systems Company, Aurora, Illinois, has recently issued a booklet explaining a visible control system which furnishes a mechanical memory to the executive's desk affording a visible schedule of work pending at all times.

Appleton Electric Company, Chicago, Ill., have just issued Supplementary Bulletin 8-A, containing 44 pages and in which are listed numerous additions to the line of Unilets and Appleton Products. This bulletin is issued in two sizes, large 8x10½ and also convenient pocket size 4x5¼. Copies will be sent on request.

The Gurney Ball Bearing Co., Jamestown, N. Y., has issued a helpful engineering bulletin giving a number of specific instances of the use of ball bearings in machine design. It is well illustrated with examples of both the ordinary and the difficult problems that have been successfully solved by the use of ball bearings. Particular attention is called to the fact that wherever radial and thrust loads occur in a shaft, they are taken care of by a single bearing with a single row of balls. Engineers or others who are interested in the carrying of shafts upon bearings which permit axial stability and at the same time rotation with a minimum of friction, will secure data of considerable value to them in their work from this bulletin.

Westinghouse opportunities for technical graduates are thoroughly explained in an illustrated pamphlet bearing that title, recently issued by the Westinghouse Electric & Manufacturing Company. This booklet describes, in considerable detail, the plan which has been developed by this company for the training of the graduates of technical schools at all of its various works. In it is included a list of prominent Westinghouse men who originally entered the company's service as graduate students, as well as a complete list of schools from which over 5,000 students have entered the employ of the company. Copies of the booklet will be sent to anyone interested on application to the educational department of the company at East Pittsburgh.

Railway Electrical Engineer

Volume 11 February, 1920 Number 2

ELECTRIC CONTROLLERS

The use of electricity has invaded practically every industry. It makes little difference what the operation may be—whether intermittent, continuous or reversing—nor what the magnitude of the power requirements are, electric motors have been designed to meet every possible demand. With the wide variety of requirements and with the corresponding variety in sizes and types of motors, comes the necessity for an exhaustive line of controlling apparatus for the purpose of connecting motors to their power supply.

The series of articles by Gordon Fox, which begins in this issue of the *Railway Electrical Engineer,* on the general subject of electric controllers will be followed with interest by those railroad electrical men whose duties are associated with the operation and maintenance of this kind of equipment. Both direct and alternating current controllers will be treated by Mr. Fox, whose extensive experience with this equipment has fitted him to speak with authority on these matters.

RAILROADS BEGIN BUYING

One of the striking features attending the return of the railroads to private control, is the manner in which they are coming into the market for new equipment. The railroads of this country as represented by the Railroad Administration have been practically out of the market for new equipment since the large orders for standard cars and locomotives were placed in the early part of 1918. The orders for locomotives for steam railroad service in 1919 totaled only about 200. Those for freight cars totaled less than 7,000, in fact, even with the large orders for private car lines in 1919 the total of all orders was only one-third of that of the poorest previous year in the past two decades, namely, 1908. Passenger car orders disappeared almost altogether and in place of annual requirements averaging between 2,000 and 3,000 cars, only 292 were ordered in 1919 for service on railroads in the United States. For the past two months, however, the picture has been entirely reversed and a buying movement of cars and locomotives is now under way which is gaining momentum daily. Thus far this year orders have already been placed for no less than 415 locomotives, nearly all within the past two or three weeks, some 8,500 freight cars and 60 passenger cars, while inquiries are now outstanding for some 200 or more additional locomotives, nearly 25,000 additional freight cars and some 300 passenger cars. This indicates that the railroads are hastening to catch up with the shortage of equipment which has come about through increases in traffic and failure to buy cars and locomotives during the past two or three years. For the car lighting man perhaps the situation has a special significance. It means that the railroads now feel themselves in a position to resume their steel passenger car program and it is evident that inasmuch as each new steel passenger car will have electric lighting, and will eventually replace gas lighting equipment, there will be a considerable increase in responsibility of the car lighting department.

THE RIGHT WORDS IN THE WRONG PLACES

There is today much talk of electrification both in this country and in foreign countries. Much of the foreign electrification work is being undertaken because of the absolute necessity for it, the scarcity of coal making it quite impractical to continue the operation of the railroads using steam as a motive power. In this country, however, where the supply of coal is very large there are many arguments which arise between the advocates of the electric locomotive and the steam locomotive. Although the price of coal has risen very considerably during the past few years, an absolute shortage of it, such as has been experienced by foreign countries, will not be realized in this country for several generations. Nevertheless, there is only a certain amount of coal to be had and it is only fair to posterity that this should be used as economically as possible. It is therefore quite proper to promote the use of electric locomotives and electrically operated trains whenever the conditions are such that the operation will come within the bounds of feasibility.

The most ardent advocates of electrification projects are naturally the men who are connected with the large electrical manufacturing companies. On the other hand the men who are to determine whether or not certain portions of any road are to be electrified are the railroad men themselves who have been for years closely associated with the operation of steam locomotives. They are familiar with the terms used in connection with these units of motive power, and not being electrical men they cannot be expected to understand the terms and phraseology of electrical engineers. It is quite logical, therefore, in attempting to show these steam locomotive advocates some of the advantages of the electric locomotive, to use such language as they can most readily understand. Translate the capacity of the electric locomotive into pounds of coal per thousand gross ton miles and the problem of convincing the old timers that there are really some good features about the electric locomotive will not be nearly so difficult.

THE LABOR PENDULUM

It is interesting to cast a retrospective glance at some of the things which caused more or less concern a year ago. Then it was that soldiers were being discharged from the army by hundreds of thousands, and indications pointed toward an overwhelming supply of labor. The labor pendulum swung from a genuine scarcity during the war to an apparent surplus shortly after the armistice. The national problem of a year ago was how to absorb our discharged army of four million men. Today we almost feel foolish for having permitted such a small matter as four million unemployed men to cause us concern. What has become of them? Have they been absorbed? They certainly have, and it is scarcely too much to say that four million more could be absorbed in like manner under the present industrial conditions.

The pendulum has once more swung back to a scarcity of labor, but this time the scarcity is not genuine—it is most decidedly artificial. In using the phrase "scarcity of labor" it would be impossible to give the word "labor" too much emphasis. There is no scarcity of laborers, at least so-called laborers, but there is a decided scarcity of "labor." The trouble is that the laborers do not want to labor. As one railroad foreman says, "I've got to have a gang of twenty-five men to do the work I used to do with a gang of eight," and right there is the kernel of the nut. If a workman of today is only going to do one-third of the work that he should do, can there ever be anything but a scarcity of laborers? It is most unfortunate that there seems to be nothing that will jolt these men from the "get it while the getting is good" attitude. There is apparently no way to bring home to them the fact that a reduction in the cost of living can never be brought about by loafing on the job. Not only are the natural sluggards ardent advocates of the propaganda of slothfulness, but what is far worse many genuine craftsmen have lent an ear to the fallacious teachings.

The gift of foresight is not given to all, but it does not require a philosopher to realize that the present status of things cannot endure indefinitely. It is unsound. Sooner or later—all too soon for those who are unprepared—the reaction will come. Swift and merciless will be the punishment dealt out to the time-wasters of today. If on the other hand, instead of killing prosperity and progress by slacking, every citizen will do his best to give an honest day's work for an honest day's pay, continued prosperity will result and many extensive, and even gigantic projects can be undertaken which will insure work for all indefinitely. Reducing production, thereby further increasing the cost of living, will destroy confidence and bring on a period of business depression and panic with much suffering. How are you using your influence to insure continued prosperity for this country?

HOW TO IMPROVE LIGHTING CONDITIONS

For the purpose of acquiring accurate information pertaining to lighting facilities as found in average industrial plants, one of the large lamp manufacturing companies recently conducted a most painstaking investigation. Several hundred plants located both in the Middle West and in the East were visited by trained investigators who not only interviewed the executives of the plants but made their own observations wherever possible. The result of this investigation, when tabulated, presented the subject of illumination from an angle quite different in its completeness from anything ever before attempted.

The fact that the lighting conditions in many railroad shops are quite similar to those found in industrial plants, makes the result of this investigation of more than passing interest to railroad officers who are responsible for the efficiency of lighting systems.

Probably the most outstanding feature of the entire investigation is the statement by the lamp manufacturing company that a lighting installation which has not been revised within the past five years is obsolete. Such rapid strides have been made in the improvement of lamps that those in use five years ago can no longer be considered as efficient. Although they were looked upon as being most successful at that time, the march of progress has passed them by and they are now supplanted by much superior units.

One of the interesting facts which the investigation developed was the relative intelligence of the men interviewed regarding efficient industrial lighting. Approximately forty-four per cent were intelligently informed; thirty-six per cent had a vague knowledge of the subject, and twenty per cent knew nothing whatever about it. More than ninety per cent of the plants are using the mazda B lamps—the most common type of lamp in use—and surprising as it is, twenty-three per cent of the plants were still using some carbon lamps.

One of the questions the investigators asked was, "How often is the lighting equipment cleaned?" In many cases the person interviewed stopped to give directions that the cleaning should be done at regular intervals thereafter. Up to the time the investigation was made, however, it was recorded that only twelve per cent of the plants kept their lamps and reflectors very clean; fifty per cent kept them fairly clean; while in thirty per cent of the plants they were dirty, and in ten per cent, very dirty.

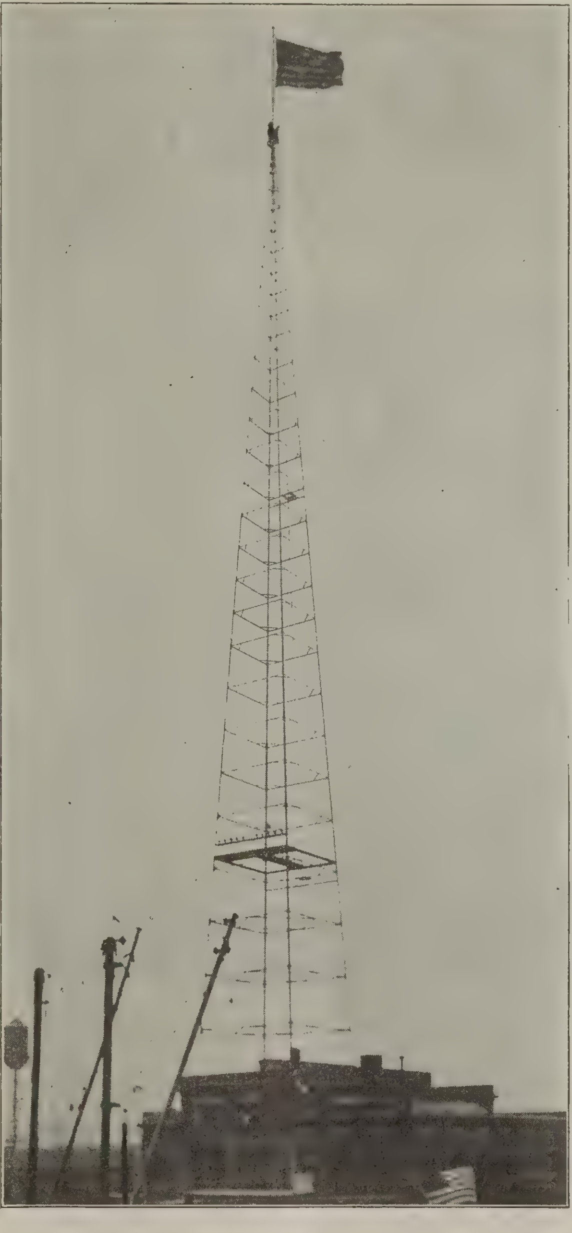
The important lesson to be drawn is that greatly improved lighting can be had by the simple expedients of using modern lamps and keeping the reflectors and the lamps themselves clean. Not only will the resulting illumination be improved, but the cost of light per foot-candle will be decreased in the inverse ratio.

Wireless Communication on the Lackawanna

How the Installation of Radio Equipment Proved To Be a Very Great Help in a Time of Trouble

EXPERIMENTS with wireless communication on the Delaware, Lackawanna & Western Railroad commenced in 1903 when an antenna was erected at Hoboken, New Jersey, on what was then Pier 2, and a receiving station installed in the telephone repair shop. At that time a glass tube containing nickel and silver filings, known as the Marconi coherer, was used as a detector or rectifier of radio currents. This apparatus represented Signor Marconi's principal discovery, and accomplished the successful development of wireless telegraphy. This detector would only function, however, when the contained filings assembled to create a certain resistance of a rather high ohmic value. When subjected to the stress of the very weak radio currents, the filings would cohere or become more closely associated, and while in this condition a local current would pass through, which would amplify the signal by reproducing it in a telephone receiver. It was even possible to operate a regular telegraph sounder or the more antique tape register. At the termination of the signal, the filings being no longer influenced, would separate and again assume their normal state of anticipation.

Although this instrument made commercial wireless an accomplished fact, it was perhaps the most delicate apparatus ever developed. When it was exposed to the slightest jar except when under stress, the filings would become so widely separated that any response to radio currents was impossible except after long and patient tapping of the tube, when their proper condition would again be restored. This is mentioned because even then, when transmission of forty miles over water was looked upon as an achievement, the project of adapting wireless in connection with trains was being considered. It was this difficulty of maintaining coherer adjustment that effectually discouraged the initial efforts in this direction. After months of experimenting it was discovered that a glass tube packed with granular unpolished carbon, with a platinum needle inserted in each end, made a satisfactory reproducer and accomplished practical continuity of reception. It would only function, however, through telephone receivers, and in those days the proposal of discarding the telephone sounder would not be considered by telegraph officers. This terminated the experiments, and nothing more was done until late in the year 1913.



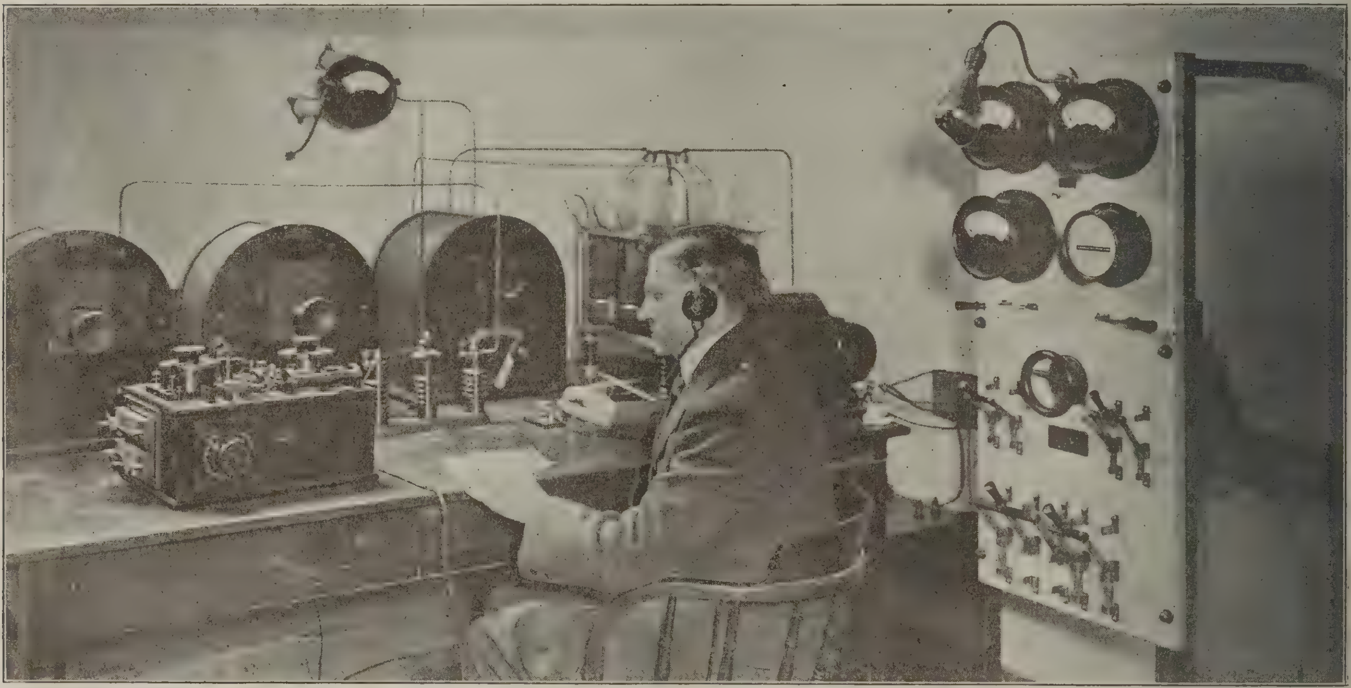
Antenna Tower at Hoboken, N. J., 455 ft. above high tide. This tower is also utilized to flood light 5 piers.

Plans for Wireless Stations

During the year of 1913, L. B. Foley, superintendent of telegraph, approached President W. H. Truesdale with a large amount of data and convincing arguments as to the progress that had been made in wireless, and recommended that the Lackawanna Railroad establish wireless stations at its principal terminals and in Pennsylvania, where the anthracite coal that is shipped via the system, is accumulated and prepared for distribution. Mr. Foley's principal argument for the need of wireless was the fact that the part of the railroad that traverses through the northeastern portions of Pennsylvania and New Jersey, is located geographically in what is known as the sleet belt; that is, this territory is frequently affected with bad sleet storms, which invariably either badly cripple or entirely destroy all wire communication. Mr. Truesdale approved Mr. Foley's recommendation, and work was soon under way.

At this time, no considerable distance of over-land wireless had been accomplished, and it was the general supposition that its field was limited either to over-water points or possibly to over flat surfaces along the coasts. It was the common belief that radio currents would not travel over mountains or through solid structures, for the reason that the waves would ground through the trees or through the material of the structures. This opinion was not confined only to the general public, but was to a large extent entertained by technical authorities.

The company was fortunate in obtaining the cooperation and active interest of David Sarnoff of the Marconi Company, and much could be said of this young man's ability and indefatigable enterprise. There were many nights, and mornings, too, when the results of the days and nights of work were decidedly discouraging. In attempting to transmit between Scranton, Pa., and Binghamton, N. Y., a distance of seventy miles, several mountain ranges intervened, and it was the experimental work in overcoming these obstacles that brought out and developed what has since been termed wireless shadows. To explain these, it is only necessary to repeat the often told story of the stone thrown into the pool of water, compare the dispersing ripples and liken their motion to wireless waves, not overlooking the fact, however, that the water *behind* the rock that projects above the surface of the pool out yonder remains undisturbed. Just so with wireless waves, if the transmission station is in New York, you may obtain strong audibility on the north side of an iron bridge or structure or mountain, near Philadelphia, but you will not hear the faintest indication of the same station's signals directly on the south side. If, however, you move further south or out of the shadow, the signals will again be heard equally as loud as they were in the first position. After these and many other details had been encountered and disposed of, the service between the two cities mentioned was perfectly satisfactory and was accomplished with less than one-half killowat of power, which was far less than had been estimated.



William Ryan, Chief Dispatcher at Binghamton, N. Y., Working With Dispatcher at Scranton, Pa.

When the Wireless Paid for Itself

The eventful year of 1914 will always bring to the mind of the telegraph and telephone men two important incidents, the sleet storm of March 1 and the World War. The sleet storm heralded its approach with a major salute in the northwestern portion of New York and the New England States during the night of February 28th, and by the following morning was firing a broadside from the District of Columbia to Halifax. By noon of the same day there was a total prostration of all means of communication inland from the coast cities, and in the case of the Lackawanna, every pole for a distance of over fifty miles was lying flat on its back and the wires were a mixed-up jumbled mass of scrap.

As has already been mentioned, the stations at Scranton, Pa., and Binghamton, N. Y., had been completed, but up to this time they had never communicated with any other. The Wanamaker store stations at New York and Philadelphia, however, had been frequently heard working with each other and hoping for the best, the railroad stations commenced calling both stores, changing the wave length from time to time. The joy can only be immagined when, after about fifteen minutes' effort, the operator of the New York store answered. The situation was explained and the operator promptly offered his services and facilities. From that moment these two stations were in continual communication night and day.

The harmonious continuations of train movement over the Lackawanna both of passengers and freight was accomplished without delay or congestion, which would have been the certain result of no communication, for it was seven days before even one wire was permanently restored. In addition to this work, numerous important messages for other trunk line railroads were handled, as well as important telegrams for individuals and news for the Associated Press.

Communication with Moving Trains

Already experiments with direct communication with trains had shown encouraging results. The principal difficulty with this work was the limited amount of wire it was possible to expose. There were only three cars that could be depended upon as regular equipment—the baggage, smoker and one day coach. The dining car, although always part of the wireless equipped train in the westward direction, returned east on another, and the Pullman cars of course were diverted to other roads at Buffalo and returned at distant dates or not at all. This limited the antenna to a natural fundamental wave length of less than 150 meters, whereas the transmitting wave length from the fixed stations was not less than 1,600 meters. Finally, however, a receiving outfit was developed that responded satisfactorily; the transmitting side of the train station responded very well from the start. Originally, the ground wire was connected to one of the trucks, but little or no radiation was obtained, which may have been due to two causes. One was the insulation of the rails of the block signal system, or if, as claimed by some, this insulation was not sufficiently high to interfere with the ground connection, it was thought it might be materially assisted by the film of oil between the journals and bearings when the train was in motion. At any rate, there was a difference of 3 to 5 amperes in radiation between standing and motion, and the faster the motion the lesser the radiation obtained.

J. J. Graf Talking Over Wireless Telephone From Scranton, Pa., to the Conductor of Train No. 3—The Lackawanna Limited

Finally, the ground wire was moved to the center of the car and attached directly to the steel body. The purpose was to use the car body as capacity, which was apparently accomplished, as no further difficulty was experienced. The average radiation was 8 amperes to the antenna, and there was no further perceptable change whether moving or standing.

This train was used in 1914 to transport the Cornell college students to the metropolis for the Easter holidays. On the trip 180 individual messages were transmitted while en route between Ithaca, N. Y., and Gouldsboro, Pa., during a period of three and one-half hours. More work could not have been done over a wire, and there was no complaint that any message failed to reach its destination.

The practicability of wireless from and to trains was often demonstrated, but a most convincing incident occurred one evening when the train was traveling between Lounsberry and Owego, N. Y., two stations twelve miles apart. About half way between them the operator observed that speed of the train was decreasing perceptibly, and called up the engineer over a telephone line that had been provided for the purpose, and inquired as to what was wrong. The latter advised that he had a broken eccentric rod and was on one side, also that, on account of the grade, he would soon stall. The operator immediately notified Scranton, Pa., 98 miles east, where the dispatcher is located. Lounsberry was instructed by wire to display his westbound order board, which action effectually protected the passenger train, which was now stalled. The dispatcher then instructed Owego to flag an east bound freight train which would arrive there in a few minutes, and instruct the conductor to shove his train into the siding there and bring his engine to the point where the passenger train was, and haul it to Elmira, N. Y., where a fresh engine would be in readiness. The train lost exactly 16 minutes, and it requires no railroad man to estimate the delay usually incident to an occurrence of this kind.

Besides keeping the superintendents of the three divisions between Hoboken and Buffalo continually informed as to the progress of the train, and arranging for additional equipment when traffic required at the various branch line and other line connecting points, a regular news distributing service was maintained, which was wirelessed to the train by the *Scranton Times* from the Scranton station, and by the *Binghamton Herald* from the Binghamton station. Market quotations furnished by Hudson and Company were handled in the same manner. A large volume of commercial business was handled, the enterprise being especially popular with commercial traveling men, who by availing themselves

Passenger on Lackawanna Limited Giving Operator at Binghamton, N. Y., Telegram to be Transmitted from Binghamton over Western Union Lines

of it saved considerable time by writing their appointments and orders while en route.

The Wireless Telephone

With the close of the year 1914, the wireless telegraph, both fixed and train stations, were working very satisfactorily, and the men of the rank and file had come to consider it as regular equipment. Once again they were working regular hours, and had gotten back to the old habit of having specified meal hours, when Mr. Foley determined that since the telephone had entirely supplanted the telegraph for train dispatching and general railway traffic purposes, telephone service must be substituted to and from trains at least, in order to obtain real results. He immediately dug up all available data and decided that Dr. Lee DeForest had accomplished some practical work with radio speech transmission, and he induced the doctor to interest himself in the venture.

With the assistance of Dr. DeForest's chief engineer, Charles Logwood, apparatus was soon developing. Two special telephones were constructed, with all apparatus except power source self-contained. The transmitters with a specially large carbon element and considerable cooling space, were exposed, as were also the three gap tungsten arcs and ammeters, one showing the amount of current passing through the transmitter or primary circuit, and a hot wire meter indicating amount of radiation. The oscillating transformer, built on the variometer principle, and the condensers, were housed within the cabinet. The receiving tuner levers were mounted on a convenient shelf and a one-step audion amplifier was located adjacent to the transmitter. The instruments were used just as an ordinary telephone except that normally the transmitter was shunted out and it was necessary to hold down a lever while speaking.

As with the telegraph, an attempt was made to drive the 40,000 cycle generator required to produce audio frequencies from the car lighting system, but the requisite speed of 4,000 revolutions could not be maintained, and finally a direct connected set, using a Sperry steam turbine, was built and set up in a special compartment partitioned off in the baggage car. A two-inch steam line was installed to the engine end of the car, and a special reinforced coupling completed the connection to the engine tank, when it connected with the steam heat line. Steam was delivered to the turbine at boiler pressure, and the reducing valve for the train line was moved from the engine to the baggage car. With this installation, no further difficulty was experienced from lack of current, and progress with the wireless telephone rapidly developed.

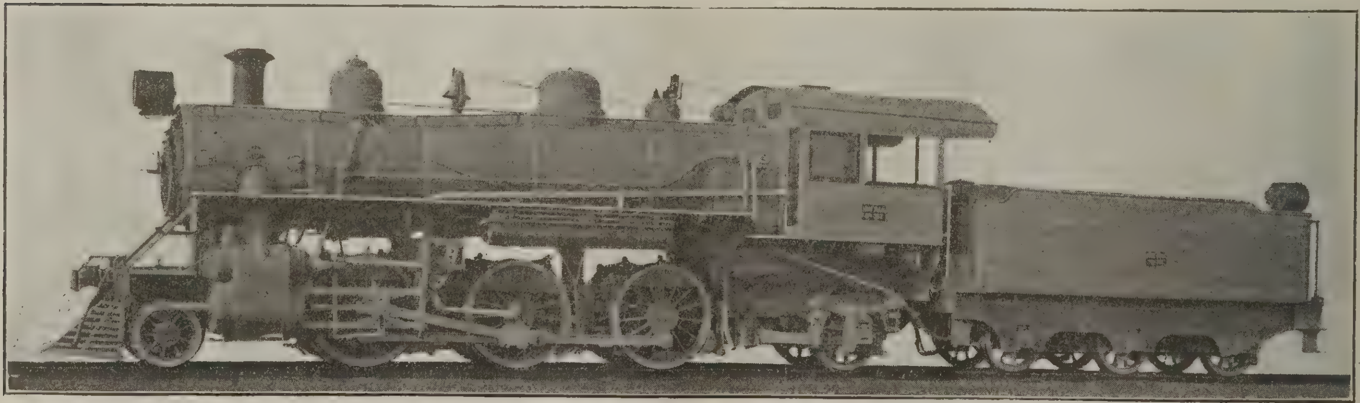
After certain wave length adjustments were made, conversations were easily maintained over distances of thirty miles and frequently more than fifty. A transformer connection was also provided with the regular telephone system, so the person talking from the train could speak directly to a person using an ordinary telephone. The conversation from the latter party, however, had to be repeated by the attendant at the fixed wireless station. The work was suddenly terminated by the government, early in 1917.

It was just previous to this time that it was discovered that the Audion valve would act as a relay of currents of considerable potentials and also transform them from direct to unlimited but controlable frequencies. This method was used by General Squires of the United States Army Signal Corps, with the assistance of American Telephone & Telegraph Company and Western Electric Company engineers in his famous wireless conversations between Arlington, Va., and Eiffel Tower, Paris.

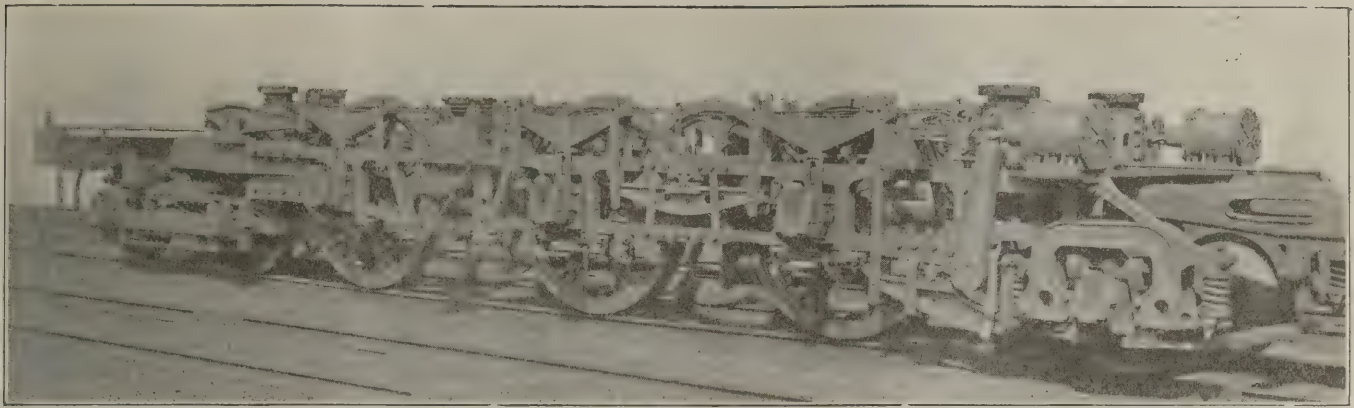
There is no doubt that with this discovery available, further experiments with train work will permit the elimination of the motor generator, and that the available lighting potential will be ample to render service for satisfactory distances, not only with wireless stations but through them with any ordinary telephone.

The Railway Electrical Engineer is indebted to J. J. Graf of the Delaware, Lackawanna & Western Railroad for the foregoing information. Mr. Graf has been closely and actively associated with the wireless developments on this road from their very modest beginnings. He has great faith in the ultimate success and use of wireless equipment in railroad service and in the light of what has already been accomplished it must be said that his faith is not unfounded. With the return of the roads to their owners on March 1st, and with ban on privately owned wireless equipment removed, there will be ample opportunity for the further development of this most useful means of communication.

· · · ·



2-6-2 Type Locomotive Built by the Baldwin Locomotive Works for the Pekin-Hankow Railway, China.



One-half of the Running Gear of the Baldwin-Westinghouse Locomotive

Electric Passenger Locomotives for the St. Paul

Ten Quill-Geared Units Will Be Used to Haul Passenger Trains Between Harlowton, Mont., and Avery, Idaho

THE ten Baldwin-Westinghouse electric locomotives mentioned in the December, 1919, and February, 1918, issues of the *Railway Electrical Engineer* are now being delivered to the Chicago, Milwaukee & St. Paul for passenger service on the Rocky Mountain division. The completed locomotive complies very closely with the design which was described almost two years ago.

The motive power equipment for the initial electrified division of 440 miles over the Rocky Mountains consisted of 32 freight, 10 passenger and 4 switching locomotives. When it was decided to electrify the division over the Cascade mountains 15 new passenger locomotives were ordered. Five of these, built by the General Electric Company, described in the December, 1919, issue of the *Railway Electric Engineer,* will be used on the Cascade division; the other ten described in this article will be used on the Rocky Mountain division. The original 10 passenger locomotives will be regeared for freight service, and a part of the 42 freight locomotives will be used on each electrified division.

The new passenger locomotives for the Rocky Mountain division will develop 4,200 horsepower for an hour without exceeding the normal rated temperature of the motors and have a normal starting drawbar-pull of 100,000 lb. The drawbar-pull may be increased until the wheels are slipped without injury to the electrical apparatus.

The locomotive consists of two duplicate running gears of the Pacific type, placed back to back, supporting a single cab. The wheel arrangement of the locomotive is 4-6-2-2-6-4, with 68-in. drivers, a rigid wheel base of 16 ft. 9 in. and a total wheel base of 79 ft. 10 in. Rigid and floating center pins have been provided to relieve the cab structure of pulling and bumping strains, all such forces being transmitted directly through the running gear.

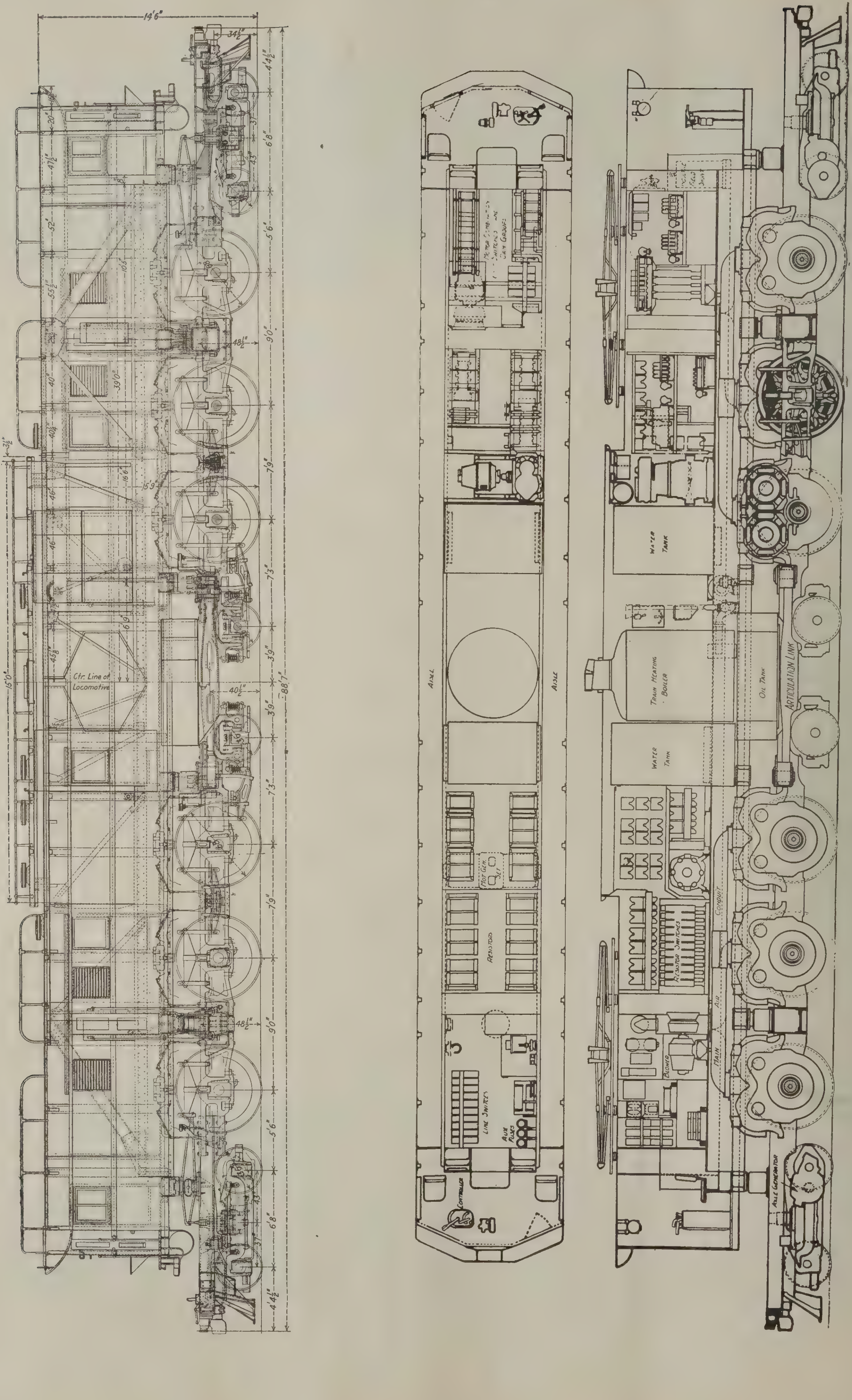
Many of the desirable features of steam locomotives have been included in the mechanical design, and in the design of the electrical apparatus the makers have included equipment which was found to be particularly good in previously built electric locomotives. These points are essentially: the limited amount of high voltage auxiliary apparatus, the stability of the operation of the main motors, the wide range of speed operation and the disposition of the apparatus in its grouping and mounting.

The articulation of the various trucks was considered one of the most important points of design. It was the endeavor to have each truck laid down so that each one would take care of itself and would not have to be led along by any of its companion trucks. During a series of tests made at East Pittsburgh, Pa., this feature of the mechanical operation of the locomotive was pronounced and the locomotive was declared to have especially good riding qualities. An extensive study was also made of weight distribution and its equalization between trucks. With this latter end in view, comparatively long spring hangers have been used so that any slight increase or decrease in their length for the purpose of shifting the load does not have any noticeable effect on the position of the locomotive springs.

The 3,000-volt direct current power is conducted through the necessary switches and resistances to six motors of the twin-armature type mounted on the locomotive running gear. The two armatures of each motor are permanently connected in series, and the control is so arranged that at least two motors are always in series, with the result that the voltage across any one armature never exceeds the value of 750 volts during motor operation. In addition to this, the control is further arranged so that all main motor fields are connected on the grounded side of the circuit, thus maintaining most of the voltage stresses on the motors practically in line with commercial usage for the past 15 or 20 years.

One motor is mounted over each driving axle on the frame of the locomotive, and power from each armature is transmitted by pinions to a gear with an 89:24 reduction. The gear is mounted on a quill shaft, which is also supported on the locomotive frame, and which surrounds the locomotive axle with an appreciable clearance. The connection between the driving wheel and the quill shaft is made by springs. One end of each spring is connected to the quill shaft, while the other engages a bracket on the spoke of the driving wheel.

This arrangement permits the driving wheels to follow the unevenness of the roadbed, without affecting gear mesh, as well as cushioning the torque of the motor. In



Side Elevation and Plan and Section of Locomotive, Showing General Arrangement of Apparatus the design of this type of quill shaft the details have been governed by the experience obtained from the successful application of a similar type of drive on the New York, New Haven & Hartford locomotives, making due allowance for the increase in tractive effort.

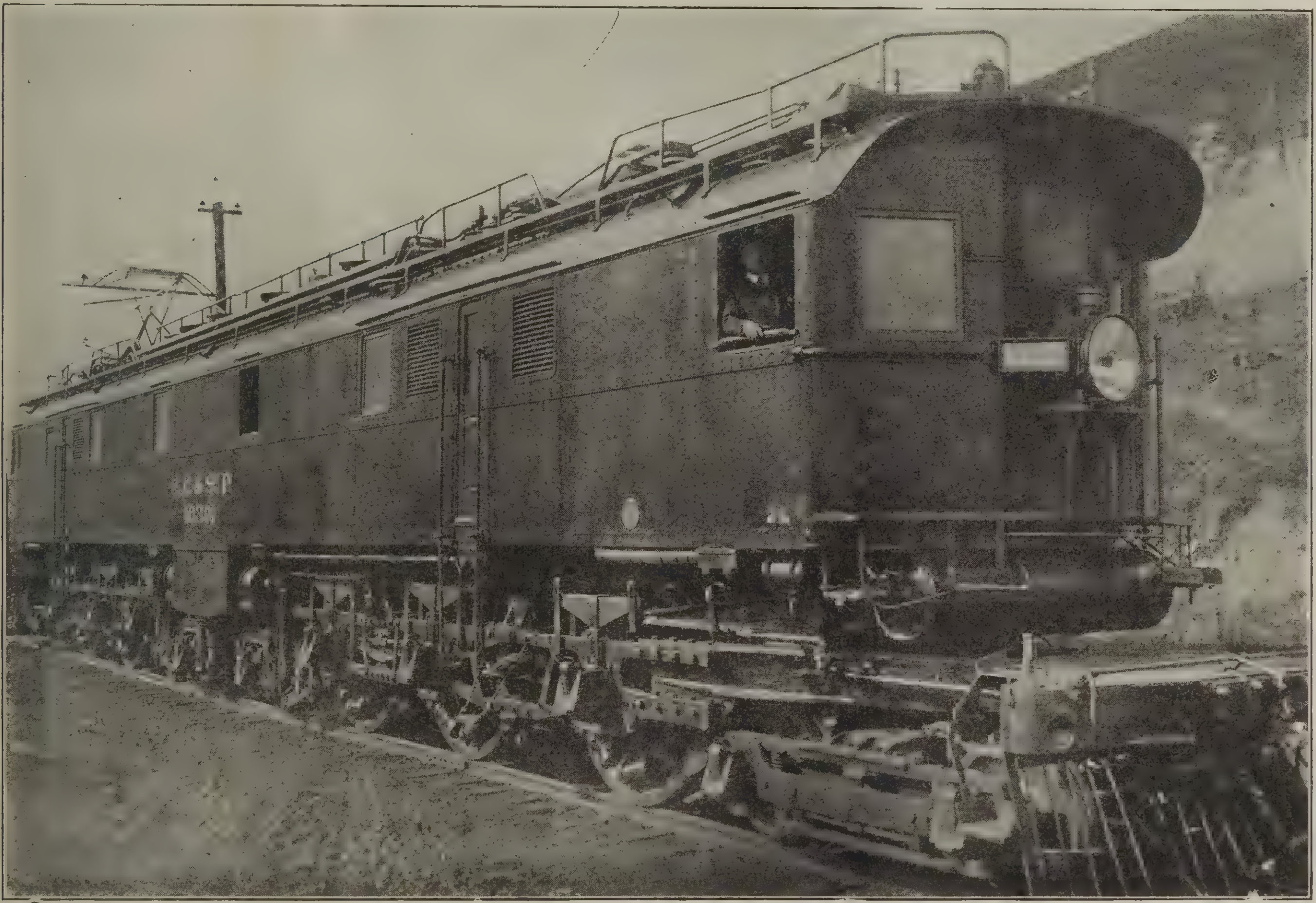
The cab structure of the locomotive, which also partially encloses the main motors, contains the auxiliary apparatus necessary for the proper functioning of the motors. Enginemen's operating compartments are located at either end, connected by aisles extending along the side of the cab. All high voltage apparatus is enclosed in compartments to give complete protection to the engine crew while the locomotive is in operation. When the locomotive is "dead" easy access is afforded for inspection and adjustment of all apparatus by removing the compartment sides and by center aisles opening through expanded metal doors into the cross aisles.

The manner of regenerating power for operation on down grades used on these locomotives embodies features which have not been used before. The main driving motors are series motors, and in order to make them regenerate power to the line it is necessary that they be separately excited. The control of the excitation of the main motors for regeneration is initiated manually by the operator from the master controller, the exciting current coming from two small generators geared to one of the axles of each bogie truck. These small generators in turn are excited from an independent source, consisting of a motor-generator set operating in parallel with a small storage battery. All of the main motors are used during regeneration. Efforts have been made in the design of main motors and the axle generators to guard against any possibility of snow getting into the windings. One of the axle generators is mounted on each bogie truck in a standard street railway motor frame.

Control

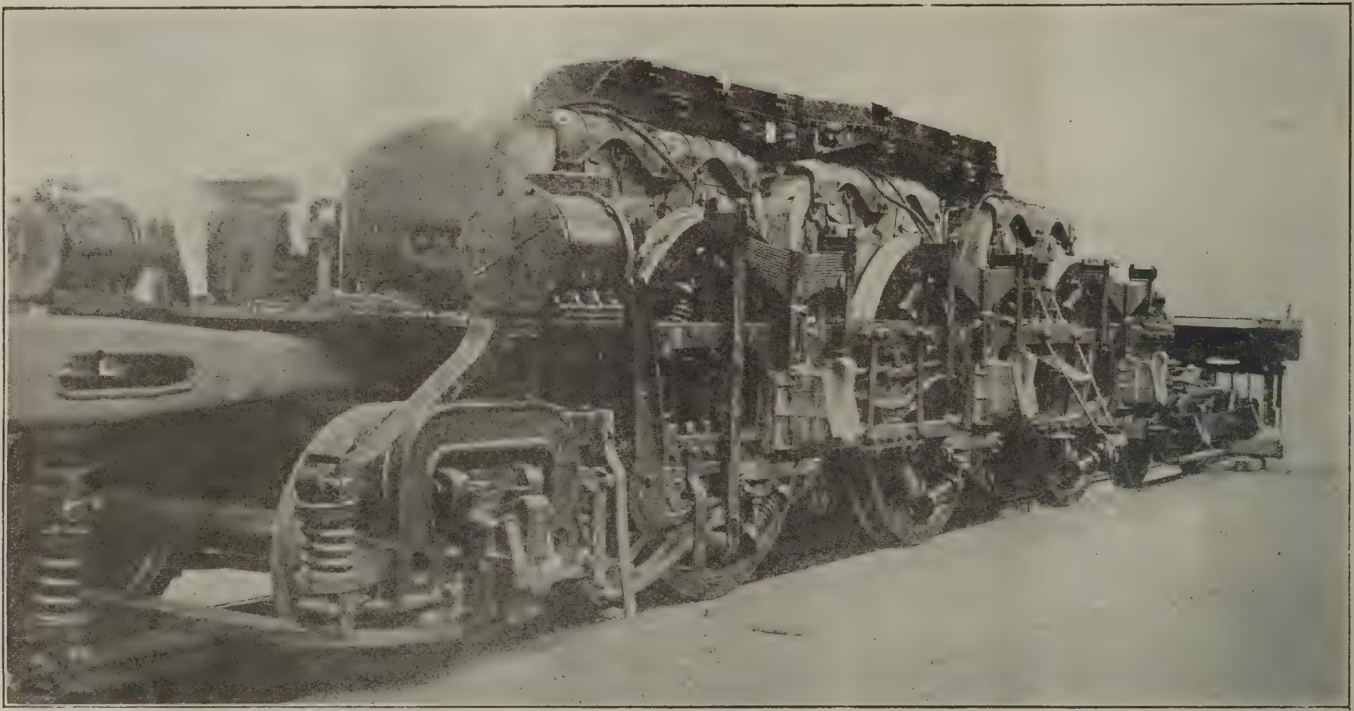
The locomotive control provides three motor combinations, giving one full series and two series-parallel connections. The two latter connections consist of two parallel circuits of three motors in series and three parallel circuits with four motors in series. In each of these motor combinations three running notches are provided, which are full field, short shunt and long shunt. This provides a total of nine running speeds without resistance connected in the circuits.

While descending a grade the excitation of the motor field is entirely under the control of the engineman and may be increased or decreased as desired, causing corresponding increments and decrements to the regenerative effort of the locomotive, thus varying the speed of the train through any desired range. The full motor capacity of the locomotive is available for regeneration, and under all conditions of grade on which it will be used it should be able to handle any train down grade that would require double-heading on the way up.


Chicago, Milwaukee & St. Paul Electric Passenger Locomotive

Auxiliary Apparatus

Power for energizing the control circuit and operating the auxiliary apparatus, a small blower motor, the motor-driven air compressor, etc., when these are not being driven by the axle generator, is obtained from a small motor generator set and storage battery which are used to excite the fields of the axle generators. The high-tension winding of this set is the only piece of revolving apparatus in a locomotive, with the exception of the main motors, which is connected to the 3,000-volt circuit. The low-tension side of the motor generator set is provided with slip rings for the generation of a low voltage alternating current for the headlight and for some of the interior cab lights. During motoring and when coasting without regeneration, the axle generators are automatically connected to the low voltage auxiliary circuit, so that the motor generator for the greater part of the time is only necessary for furnishing excitation to the axle generator field and for charging the storage battery. This reduces the necessary size of the motor generator set.



Running Gear of One Half of the Locomotive With Motors In Place

All main motor and resistance circuits are opened and closed by electro-pneumatic 3,000-volt switches which are standard for Westinghouse unit switch control. These switches are provided with blow-out coils for breaking the arc. Transfer of circuit where no high voltage current is broken is accomplished by means of cam-type contactor groups adopted for the purpose of reducing space and weight by the elimination of otherwise necessary unit switches. The control circuits of all unit switches and the cam-contactor groups are respectively interlocked electrically to prevent any improper functioning of the apparatus. All unit switches, cam-contactor groups, grid resistances, protective relays, etc., are mounted in compartments entirely closed off from the enginemen's cabs and the aisles of the locomotive, as previously mentioned.

CONDENSED TABLE OF LOCOMOTIVE WEIGHTS AND DIMENSIONS

Normal trolley voltage	3,000 volts
Total weight	275 tons
Weight on drivers	336,000 lb.
Weight on lead trucks	66,000 lb.
Weight on trailing trucks	41,000 lb.
Total wheel base	79 ft. 10 in.
Driving wheel base	16 ft. 9 in.
Maximum rigid wheel base	16 ft. 9 in.
Diameter of drivers	68 in.
Diameter of lead truck wheels	36 in.
Diameter of trailing truck wheels	36 in.
Locomotive capacity at 23.8 m.p.h. (1 hr. rating)	4,200 H. P.
Normal starting tractive effort	100,000 lb.
Normal speed on level track	55 m.p.h.
Capacity of steam boiler	4,000 lb. per hr.
Capacity of water tanks	25,500 lb.
Capacity of oil storage tank	750 gal.
Cab length	78 ft. 0 in.
Total overall length	88 ft. 7 in.

The center compartment of the locomotive is given up entirely to an oil-fired steam boiler, its supply tank and auxiliaries. This boiler supplies steam for heating trains and is capable of evaporating 4,000 lb. of water per hour. Two storage tanks for water are provided, having a combined capacity of 25,500 lb. of water. There is also a boiler also feeds radiators in each of the operating cabs. tank for the fuel oil, with a capacity of 750 gallons. The boiler also feeds radiators in each of the operating cabs.

Electric Regeneration on Swiss Single Phase Railways.—The first experiment, on the recovery of the electric energy, which the braking or down-grade movement renders available, was made on the Lotschberg line of the Swiss Federal Railways, on June 27. The system tried was that of the Maschinenfabrik Oerlikon, and the success is described as complete. The tests were conducted with the locomotive which the Oerlikon Company, in conjunction with the Lokomotivfabrik Winterthur had built for the Gotthard Railway, and which, since May, has been in regular service in the Bern-Thun Railway. In the tests the engine was run at different speeds, up to 70 km. per hour, down hill, first empty, and then with a load of 310 tons, without making use of the mechanical brakes or of any brake resistances. It is said that the remarkably simple devices operated to complete satisfaction from the start, and the detailed account of the tests, will hence be a matter of considerable interest.

Multiple Unit Equipment for English Railway*

Description of All Metal Cars Offers Opportunity for Comparison with Similar American Rolling Stock

THE problem of the designers of multiple unit equipment for the Manchester-Bury section of the Lancashire & Yorkshire Railway was that of designing all steel electric cars for operation from a 1,200-volt third rail. The maximum grade on the line is 2.04 per cent and the result of tests made with a train consisting of one motor coach and one dynamometer car weighing 54 and 32.6 tons respectively, showed a maximum speed of 40 miles an hour and a maximum acceleration of 2.52 ft. per sec.

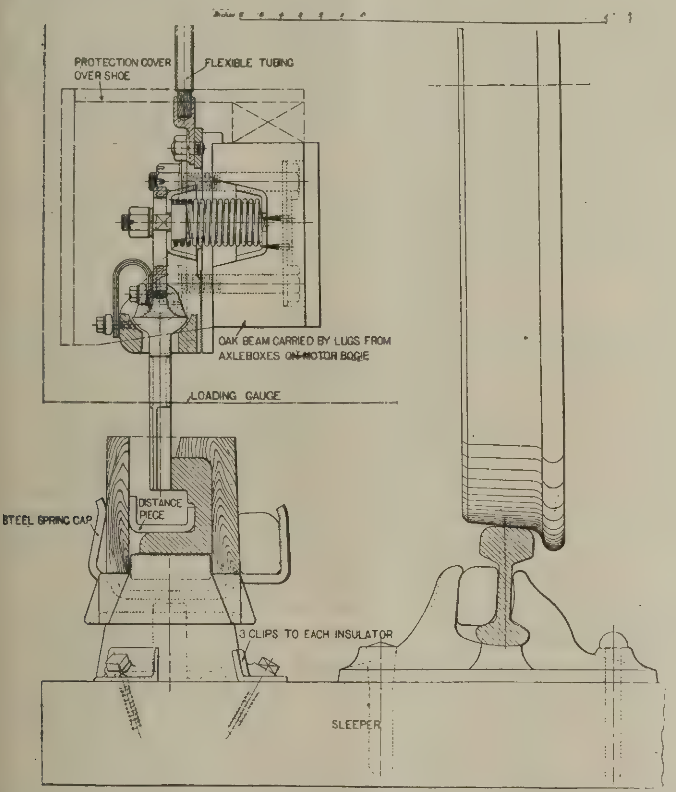

PROTECTION COVER OVER SHOE
FLEXIBLE TUBING
OAK BEAM CARRIED BY LUGS FROM AXLEBOXES ON MOTOR BOGIE
LOADING GAUGE
STEEL SPRING CAP
DISTANCE PIECE
3 CLIPS TO EACH INSULATOR
SLEEPER

Fig. 1.—Cross Section Through Conductor Rail Showing Contact Shoe

The contact shoes, which collect the 1,200-volt current from the live rail are directly connected to the main trolley cables running along each side of the car. These trolley cables are paralleled, and connections are taken through the main knife switches and fuses, then through the circuit breakers to the contactors, resistances, motor cut-outs, reversers, brushes, and finally to the motors, returning to the earth by a connection on the field frame. Another connection from the trolley cable through a knife switch and fuse to the starting switch of the rotary transformer furnishes an auxiliary current at 100 volts for the operation of the contractors, pump-motors, lighting and auxiliary apparatus on the car, with the exception of the heating, the latter being taken direct from the trolley-cable. The heating units are protected by grounded metal covers.

Contact Shoes

Each contact shoe is secured to a beam fixed between the axle-boxes of the motor-trucks. The kind adopted, shown in Fig. 1, bears upon a rail known as the Aspinall fully protected side-contact live rail. The shoe is pivoted horizontally and parallel to the center line of the cars and is allowed to move freely between stops. A pressure of 25 lb. is maintained on the rail by a spring placed between the top of the shoe and the shoe beam.

Protective Devices

An effort was made to find suitable means for isolating the main trolley cable from the contact shoe, either by a fuse in the connecting cable between the shoe and the trolley cable, or a switch of the circuit breaker type. After a thorough investigation it was decided that any such method would be useless, because if fuses were used, four would be required on each car, and at some period it would be possible for the whole of the current for the train to be carried by one shoe, which would necessitate each fuse being capable of withstanding the whole of the current for the train without fusing.

Owing to the fact that the current at starting is about 2,000 amperes, it would be more than likely that the substation circuit breaker would open before the shoe fuse was blown. In addition to this, the blowing of a fuse at 1,200 volts is attended by an explosion which, unless the fuse is well protected, might set up an arc between the shoe or its connecting leads and some grounded portion of the truck. Similar reasons apply to the use of the

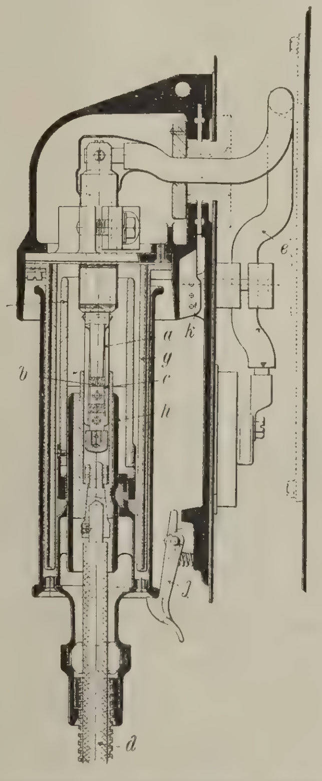


Fig. 2.—Arrangement of High Tension 1200-Volt Coupler

---

* The substance of this description was taken from a paper presented by George Hughes before the Institution of Civil Engineers.

circuit breaker and in addition, the housing for the circuit breaker would require a compartment 3 ft. by 3 ft. by 2 ft. in size, which, to be satisfactory, would have to be quite close to the contact shoe.

Trolley-Cable

In order that the car be "all-metal" in every sense of the term the question of housing the trolley cable gave rise to considerable investigation, and much effort was made to find a substitute for Jarrah† timber, which has been used for some years quite successfully on the Liverpool-Southport 600-volt section of the Lancashire & Yorkshire Railway.

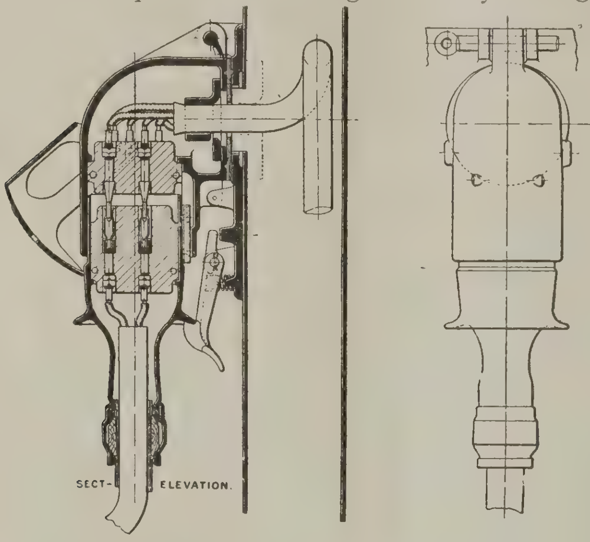


Fig. 3.—General Arrangement of Low Tension Control Coupler

Exhaustive tests were made with various kinds of housing materials, but it was found that Jarrah fulfilled all of the conditions most successfully. It is an additional insulation, it will not burn with a flame and it smothers an arc when formed.

Couplers

The electrical connectors used between cars are of the plug and socket type and are so located that when a train is made up the plug of one car is directly opposite the socket of the car next to it.

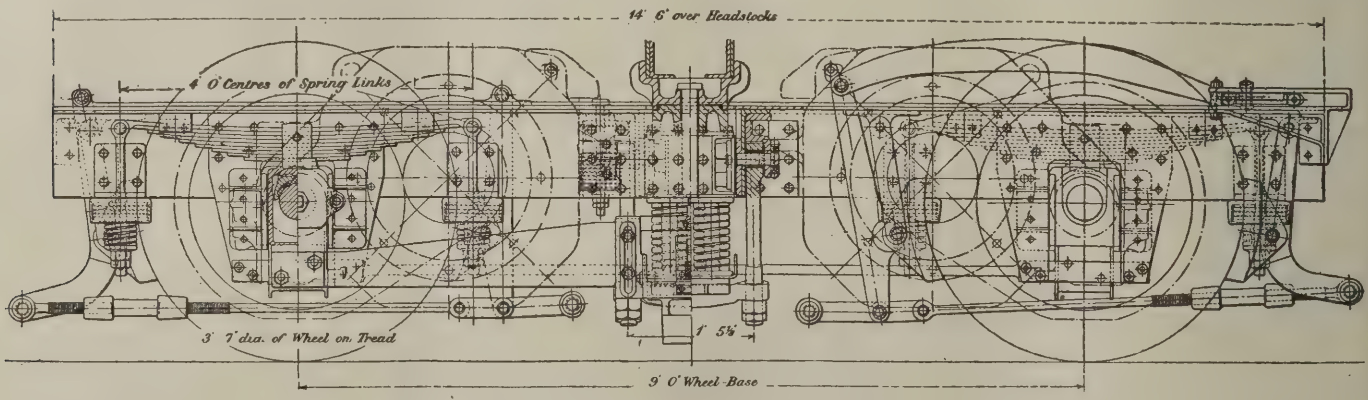


Fig. 4.—Side Elevation of Motor Trucks

The high-tension couplers are connected directly to the 1,200-volt cable running along each side of the car. A cross-sectional diagram of one of these couplers is shown in Fig. 2. The plug portion is fixed to the car and the contact consists of a copper rod which is split by four saw cuts. Tension is maintained by the small springs *b*; *c* is the socket which is a part of the loose portion of the coupler; *d* and *e* are the connectors to the main trolley-cable; *f* and *g* are fiber insulating-tubes, and *h* is a mica insulation wrapped around the block forming the socket *c*.

When the plug and socket are in position, as shown in Fig. 2, a spring catch, *j*, comes into operation, which makes it impossible for vibration to cause the plug to fall out of the socket. The plug portion fixed to the car is hinged and held in a vertical position by a small pin, *k*.

There are two low-tension couplers, one of which is shown in Fig. 3. One set of the low-tension couplers is connected with the 100-volt cable from the rotary transformer and the other low-tension set is connected with a multicore cable which controls the connectors. Both of the low-tension couplers are similar in construction to the high-tension couplers, but are smaller. When the loose portion is not in position it is held up by a dummy holder. The low-tension connecting cables between cars are covered with rubber tubes as a protection from weather.

In connection with the bell-circuits, which are worked from a battery of accumulators, there is also a small coupler in the center of the car.

Rotary Transformer

The rotary transformer is located under the car and is attached to the underframe. It is a compound-wound machine of 10-kw. capacity and has a single armature with two commutators, one at each end. There are two windings on the armature, a high-tension winding being placed in the same slot with and above the low-tension winding. This machine is operated on the high-tension motor side by an automatic control-switch and is protected by a knife switch and fuse.

It has been found necessary to equip the rotary transformer with an automatic starting device because when short trains are in use there may be gaps in the live rail at junctions and cross-over roads. In such cases the current will be cut off for a short period and would cause the motor portion of the rotary transformer to flash over and give trouble if it were not so equipped.

High-Tension Equipment

A compartment, which is on the opposite side to that of the motorman, contains all of the 1,200-volt portion of the control equipment. It completely isolates the whole of the high-tension equipment from the remainder of the car by sheet-metal walls and door. All apparatus in this compartment can be operated manually from outside, and the door of the compartment is interlocked with the main isolating switch so that it is impossible to open the door when current is on.

---

† The mahogany gum tree of Southwestern Australia.

There are two main circuit-breakers on each car. They are of the magnetic shield type, insulated for 1,200 volts, and are so designed that they can be set or reset from the motorman's compartment. This is done by means of two coils on a breaker which are energized momentarily from the 100-volt auxiliary circuit through a small two-way switch. A trip coil is fitted close to the overload release coil and operates the same mechanism. The resetting is done by another coil which pulls the contact brush onto the contact plates and sets up a toggle. A magnetic blow-out coil is fitted above the contacts and two arcing horns, protected by soapstone shields, are provided.

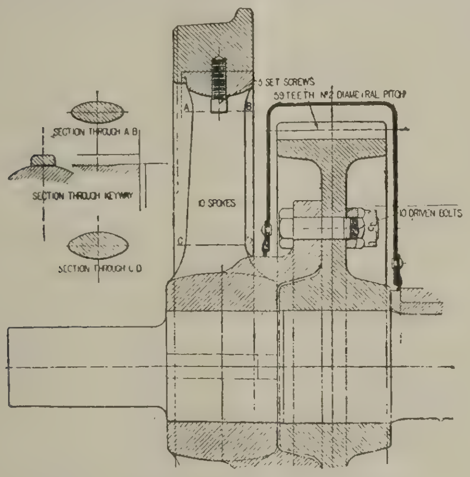


Fig. 5.—Section of Wheel and Gear

Electrical Control Equipment

The control equipment is of the shunt multiple unit type, the contactors being operated from a 100-volt circuit supplied by the rotary transformer. Either automatic or manual operation may be used at will in the forward position, and manual only in the reverse. A supplementary field control is used for higher speeds.

When the controller handle is placed in the series or parallel notch the main contactors operate automatically in sequence until the series or parallel running positions are reached. The automatic operation is controlled by means of relays which are governed by the main motor circuit and so arranged that no succeeding contactors come into operation until the motor current has dropped to a predetermined value. The current sequence of operation of the contactors is controlled by electrical interlocks.

Automatc control is installed to prevent the motorman from exceeding the normal acceleration current by operating the controller handle too quickly. It is not a unit saver. Its adoption makes necessary the use of relays and a large number of interlocking secondary contacts. Experience has shown that much attention is required to keep these in effective working order, and the maintenance of relays and extra contacts tends to exceed that of the main contacts. The question of additional motor maintenance, however, due to overloading, is minimized in motors of modern design, especially when the motormen become efficient.

Each motor and each trailer car is provided with two master controllers. There are nine positions of the controller handle, four series notches, four parallel notches, and one for supplementary field control.

There are four positions of the reverser handle: ahead manual control, ahead automatic control, off, and reverse control. Two reversers are fitted in each motor car and each reverser controls two motors. They are solenoid operated from the master controller, the movement of the solenoid coil rotating a spindle to which brushes carrying two mica insulated bars are secured. These bars carry contacts and receive a rotary motion from the spindle, making connection with the contact fingers secured to two mica-insulated bars situated on each side of the movable contacts, the fixed contact fingers being connected with the motors.

There are two groups of contactors on each motor car, one at either end, and each group controls two motors.

Motor Cut-Out

Each motor car is fitted with two motor cut-outs. Each cut-out controls two motors and is manually operated. It consists of two fixed mica-insulated bars supporting contact-fingers, with a movable contact-barrel between them. Connections from the contactors and motors are made through the contact fingers, and when the contact-barrel is in the normal position both motors are in circuit. When the barrel is moved to the right, one motor is cut out, and when it is moved to the left, the other motor is cut out.

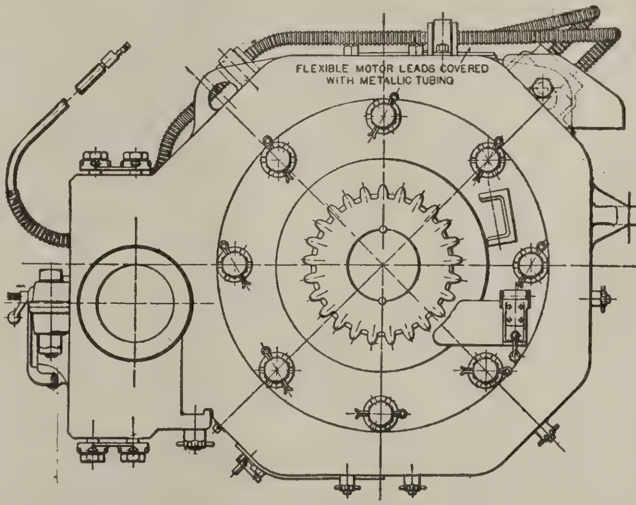


Fig. 6.—End Elevation of Motor

Motor Trucks

A side elevation of one of the motor trucks is shown in Fig. 4. The frames are built of 12-in. by 4-in. by 0.6-in. angle for sole bars and transoms, and ⅞-in. plates for horns.

The greatest advantage claimed for the built up frame is low maintenance cost. The truck is stiffly gusseted at the top, and horn-plate ties take the place of any necessary trussing. The design is the result of the development of the built up frame truck, and is calculated to withstand vibration and inertia stresses due to starting and stopping and centrifugal forces at curves.

The gear wheels are pressed on to the axles and also bolted to flanges cast on the running wheels, as shown in Fig. 5. This relieves the axle of a considerable portion of the torsional stress. The road wheels are of the standard locomotive spoke pattern, having 10 spokes designed of sufficient strength to withstand the pressure due to tire shrinkage and the shock caused from the fact that a considerable portion of the weight of the motor is carried directly on the axle. The wheels are 3 ft. 7 in. in diameter.

The bolster rests on two sets of four helical springs, and is of the box-girder form, being built of 8-in. by 3-in. channels and ½-in. plates; the rubbing-blocks are fitted with detachable case hardened plates for renewal purposes. The bolster has a lateral movement of 1½ in. each way. The swing links are of forged steel and of ample proportion. The upper ends are bushed with case-hardened steel ferrules.

A laminated type of bearing springs are used which have auxiliary helical and rubber springs at the ends. The helical springs have an entire absence of friction, and are very responsive in their movement, while the laminated springs are slow moving; hence a combination of these two gives good riding qualities and minimizes oscillation.

The wheel base is 9 ft., which allows room for the large motor and for a long spring base. A double brake-block arrangement is fitted, thus eliminating unequal stresses in the axle. The outside brake hangers are cranked, so as to leave free access to the adjusting turnbuckles. The standard English practice of attaching the brake block direct to the hangers is adopted. The mechanical advantage of the brake is 8 to 1, giving a total block pressure of 65 per cent of the total weight of the car.

Motors

Each truck is equipped with two 200-hp. motors, mounted and geared to the axle through spur gearings, the ratio being 59 to 25. The usual type of nose suspension of the motor has been adopted so that half of the weight of each motor is supported by three sets of concentric rubber springs, and the other half is borne directly on the axles. Thus half of the weight of the motors is spring-borne. This method of suspension was adopted because of its simplicity. The motors are built with solid steel frames and interpoles. The field coils and interpole coils are enclosed in brass cases and solid mica insulation is used in the armature coils.

Brake Equipment

The vacuum type of brake equipment is used, and the vacuum is maintained by a pump having a swept volume of 90.8 cu. ft. per minute, capable of releasing the brake in 12 seconds. There is a brake valve in each motorman's compartment, which is connected to the trainpipe. The brake valve includes vacuum-pump control switch and "dead-man's handle."

The motorman is compelled to retain his hold on the handle when running; should he release it, the handle rises, the vacuum brake is applied, current is cut off from the main motors by a tripping switch below the valve body, and the pump motors are stopped should they happen to be running. The handle has a range of movement without tripping actually occurring, which enables the motorman to move his wrist slightly from time to time without danger of setting the brakes and thereby rest his hand.

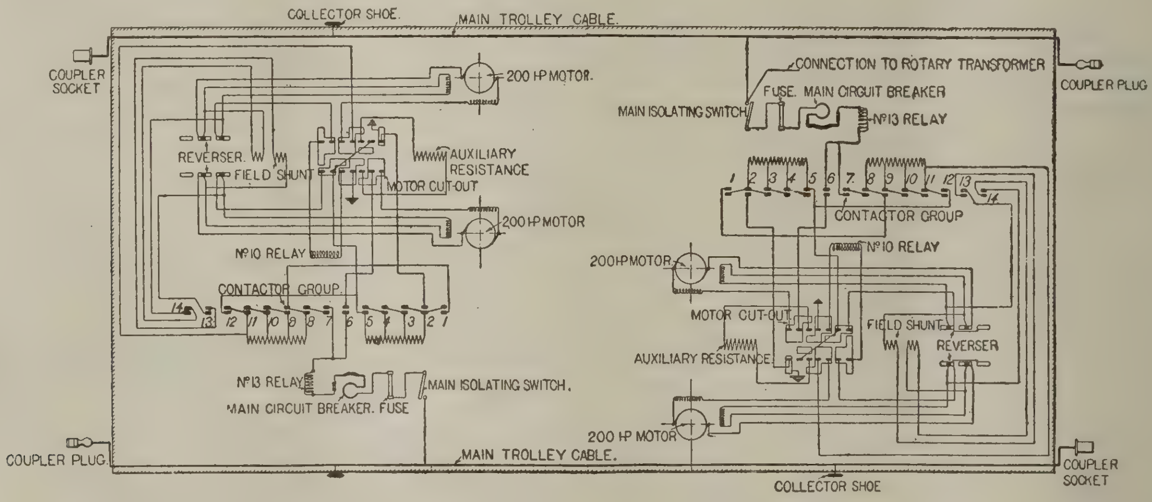


Fig. 7.—Diagram of 1200-Volt Wiring

Wiring

A simplified diagram of the high-tension wiring is shown in Fig. 7. The high-tension 1,200-volt cables are kept separate and distinct from the low-tension 100-volt cables, the former being placed in Jarrah troughing well below the car floor and the low-tension cables immediately under the car floor.

Code signals between the guard of the train and the motorman are communicated by means of bells, one of which is in each motorman's compartment, with pushes suitably placed for easy access by either the guard or motorman. Current for these bells is supplied by batteries of accumulators, 14 motor cars being fitted with "Ironclad-Exide" cells, and 14 with Edison cells. There are 6 "Exide" cells to a battery, having a discharge capacity of 150 amperes in 5 hours. They are built up in lead-lined wooden boxes and supplied in two crates with three cells in each crate, the crate being fitted with outside terminals. There are 10 Edison cells to a battery, and these also have a discharge capacity of 150 amperes in 5 hours. These cells are supplied in two crates with five cells in each crate, the two crates of cells being placed in a sheet-iron case, which is suspended from the underframe of the car. This case is also pivoted on one of the suspending arms, so that when the cells require recharging they can be removed quite easily.

Six spare batteries of each type are kept fully charged or on charge, so that exchange of batteries can be effected in a very short time whenever a car is in the repair shop. A battery can also be used for emergency lighting in case of failure of the lighting circuit.

The lighting is taken from the 100-volt circuit supplied by the rotary transformer. Each motor car is lighted by thirty-three 35-watt lamps.

Power for heating is taken directly from the 1,200-volt trolley cable, and there are 20 heaters arranged in series in each car. Each heater has a voltage drop of 60, and the current consumed is 7 amperes per heater. Each heater contains 77 feet of No. 17 S. W. G. high-resistance wire, enclosed in a perforated metal cover. The heaters are arranged along the side of the car between the seats.

Maintenance of Equipment

The operation of the train is so arranged that the vital parts of the electrical equipment, motors and motor trucks are looked over twice a week. During this inspection, the rotary starting switch, contacts, circuit breakers and contact fingers are cleaned if necessary. A weekly examination is made of the controllers, reversers, motor cut-outs, motor brushes and the commutators. The brake rod, springs and oil arrangements on the motor trucks are also examined.

The cars are given a general overhauling every six months, at which time the car bodies are removed from the motor trucks, the motors taken out, the armatures removed, the commutators examined, turned up and the mica undercut if necessary, the brush gear overhauled, the armature windings cleaned, blown out and varnished, the steel frames cleaned and connections examined, the motor trucks inspected, the wheels turned up if required, and the bearings adjusted. The electrical equipment is thoroughly overhauled, every individual piece of apparatus being inspected and the necessary parts repaired or adjusted and the wiring of the car inspected and put in order.

Once every twelve months the equipment is overhauled, the contactors are taken down, the fingers being taken off and renewed where necessary, and the controller and all other equipment is dismantled and renewed, cleaned and adjusted.

According to the author, this periodical examination has contributed materially to efficient service.

World's Greatest Radio Station

Construction work on the giant La Fayette radio station being built at Bordeaux by the American navy is finished and installation of the electrical equipment will be completed next spring, it is announced. This will be the largest and most powerful wireless station in the world, according to naval authorities.

Construction of the plant began about two years ago, when it was believed that the war might continue for a long time and when the necessity of ample communication facilities between the United States and the American forces in France was clearly evident.

When the armistice was signed the French government asked the United States Navy to complete the station, because the navy was familiar with the plans and had a force of experienced workmen on the spot. The French government, however, agreed to meet the entire cost of construction and to take over the plant.

The aerials of the station are swung upon eight steel towers, each about 900 feet high, almost equaling in altitude the famous Eiffel Tower in Paris.

It is expected that the station will be of such power that any amateur or professional station in the world, regardless of static conditions, will be able to pick up its transmission. The electrical installation is entirely modern, and the station conceals secrets that the French government is guarding closely. No one is permitted to enter the plant except the trusted men who are at work there.

* * *

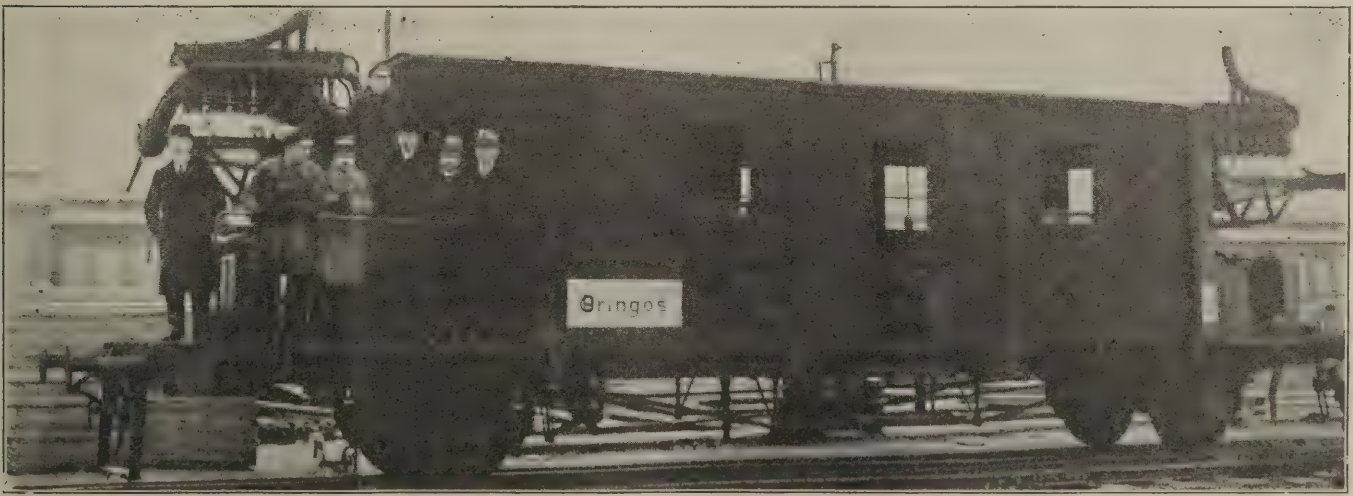


Photo from International Film Service

This Car Driven by Air-Plane Propellers Is Said to Have Made a Speed of Nearly 200 Miles an Hour. It is the Invention of Dr. Otto Steintz of Germany

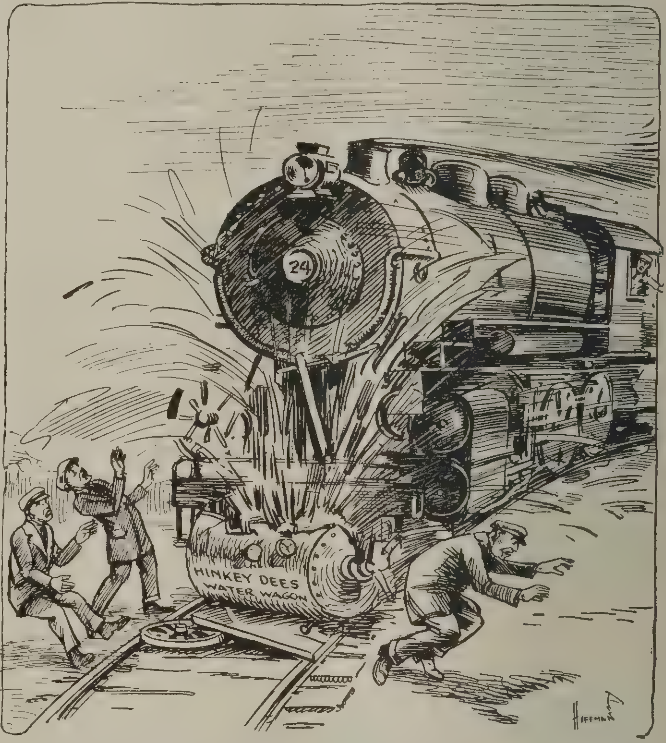
The Trials and Troubles of a Car Lighting Man

Hinkey Dee and the Yard Master Develop a Remarkable Machine Which Comes to a Sad Finish

ONE day the boss stopped me every twenty minutes for six hours straight and each time he asked me if I had nothing to do but talk to the men. He said I was like a Victrola with one long continuous record on. The last time he said: "Well, here you are making another speech, Hinkey Dee. If hot air was music you would be a full orchestra; it's a pity they didn't have you in France to gas the Germans. Now, look here, Hinkey, if I catch you talking to the men and stopping the works any more today, I'll have to take some action." "All right, boss," says I; "you'll not catch me any more, because I'm going to resolve right now to stop tellin' these fellers all about electricity. I'm the only one around here that knows all about car lightin', and when these fellers all get stuck they come to me for advice. Why, I can do more work and better work than any six men around this place. I know car lightin' from A to Z, and I can do the work. You accuse me of talkin' too much, but I'll tell you right now that I have a mighty good head on me shoulders, and I can think quick. That's why I'm so good on car lightin'." "All right," says the boss, "I know you're good, Hinkey; but for heaven's sake, get busy and do something."

Then I took me tools and all and started to walk down the yard when who do you suppose come along? Why, to my surprise, it was his honor the yard master. I didn't say nothin', because I wasn't sure if he'd feel like speakin' to me or not. Yes, sir! Sometimes yard masters is so busy they can't see you, and if you didn't give them the right of way, they'd walk right up your back and run over you. Didn't you ever see a yard master runnin' up and down the tracks, yellin', jumpin' and wavin' his arms like a nut? Well, then's when he's busy and has to carry on like that because he's too busy to use his brains.

But this time he wasn't busy, I guess, because he said, "Hello, Hinkey Dee, old top. I suppose you're goin' to do some noble work." I said, "Yes, I'm goin' up here to flush a set of batteries." "Why, what's wrong that you have to flush them, Hinkey Dee?" says the yard master. "Are they all out, not enough juice?" "Yes, that's right," says I, "not enough juice." "Well, Hinkey," says the yard master, "I don't know how it is now, but I do know that when you get through lookin' at it, it will be all right, or my name isn't yard master." "You're right," says I. "I know these cars from A to Z." "By the way," says the yard master, "what's that stuff you're carrying in that bucket? Is that the juice?" I says, says I, "Yes, that's distilled water." "Is that so?" says the yard master. "Do you always carry it, and does it do the trick, and is it heavy?" "Heavy," says I, "why, just pick it up." The yard master picked up the bucket and said, "By golly, that's heavy as lead! Why, that is three times as heavy as regular water that ain't juice is." I said, "Say, yard master, why are you askin' so many questions? What have you up your sleeve? Out with it." "You're a good guesser, Hinkey Dee," says the yard master. "I have something up my sleeve. I have an idea that will save you a lot of work and fix the car in a jiffy. Now, Hinkey, just how long does it take you to get that juice and carry it to fill a car?" "Well," says I, "I suppose it takes me two hours to walk from here to the battery house, which is one square away, and get this bucket full and walk all the way back." "Just think of it," says the yard master. "Well," says he, "my idea is to mount a big tank on wheels and fill it with distilled juice and fix it and charge it at the charging place like you do, and then when a car arrives without no light just rush up, open the doors, squirt the hose into the car and in a few minutes she'd be all full of juice and ready to go out again. Just think of the time saved. Why, I could have the cars ready all the time with lots of light and you wouldn't have to carry the juice at all, Hinkey. How many cars do you suppose a big tank would fill, Hinkey?" "Well," says I, "I suppose about fifty." "My goodness! That many?" says the yard master. Then I says to the yard master, "I'm goin' down right now and try that scheme. Why, yard master, you charmed me with your brains. Your head, I believe, is as good as mine. I was just thinkin' of that very same idea when you spoke of it, so you see we both have the same ideas, don't we, yard



I jumped one way and Eddie Ram and Jimmy Goat the other—Biff, Bang, Bang, Boom and—Talk about Niagara Falls * * * * master?" "I guess we do, Hinkey," says the yard master; "let me know how you make out with it."

Then I went to the battery house and told all the boys of my idea and they laughed at me. The boss happened along and said, "Well, here you are, gassing again." I said, "Boss, I have a new idea." He said, "Well, if it's yours, it must be great," and walked away. I said to meself, "Well, he who smiles last has the last laugh," and made up me mind right then and there that I'd show these fellers a thing or two.

I got Jimmy Goat and Eddie Ram to help me, and in two days we were all ready to start. I had painted on the sides of the tank.

HINKEY DEE'S WATER WAGON
FOR CHARGING 'EM QUICK.

So's everyone would know it was my idea. We got all ready to start out, so I told the boss and yard master, and they both said they would go along to see it in action. The fellers all wanted to see it, too. So when all was ready I pulled the wagon and Eddie Ram and Jimmy Goat pushed. The whole gang followed. We had to cross from one yard to another, and just as we reached the crossing I noticed an engine comin', I yelled to Eddie Ram and Jimmy Goat to stop, but I guess they didn't hear me because they kept a-pushin' and landed the wagon on the crossing, square in front of the engine. I jumped one way and Eddie Ram and Jimmy Goat the other—biff, bing, bang, boom, and—talk about Niagara Falls. Eddie Ram said he was there once, but that water didn't fly half so fast there. I told them all that I thought Eddie Ram and Jimmy Goat were jealous of me, and did it on purpose, and I made up me mind right then and there to make another one and not let anyone touch it.

Lookin' out the window I saw Jimmy Goat and Eddie Ram going up in the air and the water wagon was blown to pieces

In short order I had another one made and called the yard master and the boss and told them about it. They said they'd go along and see it work. The boss, yard master and me pushed the wagon up to a car that tested only eight volts. "Here's a Jim dandy," says the yard master; "let's charge this one first." I pulled the hose off the wagon, opened the battery box doors, and squirted the juice into the batteries until they flooded over. The boss said, "Hinkey Dee, you put too much in those cells." But the yard master said, "No, he didn't; I want them chuck-a-block!" Then the yard master rushed in and tried the lights and said I didn't put enough in 'em because the lights was just as dim.

The boss said he thought we were both crazy, and that the lights wouldn't come up until we charged the car. Maybe the yard master didn't get hot under the collar. You know these yard masters is boss, and I guess the boss forgot hisself. The yard master said to the boss, "Now, don't get smart. I invented this, and I know it will work, won't it, Hinkey Dee?" I say, "Yes sir, she'll work all right." The boss walked away disgusted, and didn't say nothin'. It was a terrible cold day, and me and the yard master went inside the car to get warm. "Looker here, Hinkey Dee," says the yard master, "let's try another car." "Sure," says I. So when we got warm and all we started for another car, and tried to charge it. This time the juice wouldn't run. "By golly, yard master," says I, "I believe its frozen." "No, sir!" says the yard master. "I know electricity don't freeze!" "Oh, yes it does," says I. "No it don't." says the yard master. "I know it don't, because I read it in a book one time." "But what kind of electricity was it?" says I. "Oh, just ordinary electricity," says the yard master. "But this ain't that kind," says I; "this is water electricity." "Oh, well, then that's different. I never thought about it bein' water electricity." "Yes," says I, "she's water electricity." "Now, Hinkey Dee, what is water electricity?" says he. "Water electricity," says I, "is the kind you use in storage batteries that lights the cars." "Oh, I see," says the yard master. Then he said, "Hinkey Dee, you know a lot." My, but that made me feel good when he said that, because you know he's the boss of everybody.

"I guess you're right, Hinkey Dee, she's frozen," said the yard master. "Suppose we try to thaw it out." "Sure," says I. So we go get two gasoline torches and started to thaw the water wagon. Pretty soon the juice started to run again, and we both yelled, "Good! Here she comes!" Then we got our gloves on and got ready to start again, and what do you think, before we could get it goin' the blamed thing froze up solid again. "I have it," says the yard master; "let's arrange a fire box under the wagon just like a locomotive; then we can keep the juice warm, and it can't possibly freeze." "Great," says I; "let's go." So we started in, and in short order we had the cutest little fire box made and a charcoal fire blazing away under the wagon.

"Let's go inside and get warm while she's heating up," says the yard master. "All right," says I. So we both went inside and set down. I guess we both went to sleep at the same time, because the next thing we both remember is bein' raised two feet off the seat by an explosion. Lookin' out the window I saw Jimmy Goat and Eddie Ram going up in the air and the water wagon blown to pieces. We rushed out and found Eddie lying with his feet danglin' out of a rubbish can between the tracks and poor Jimmy Goat was hangin' on a hook on a telegraph pole by the feet.

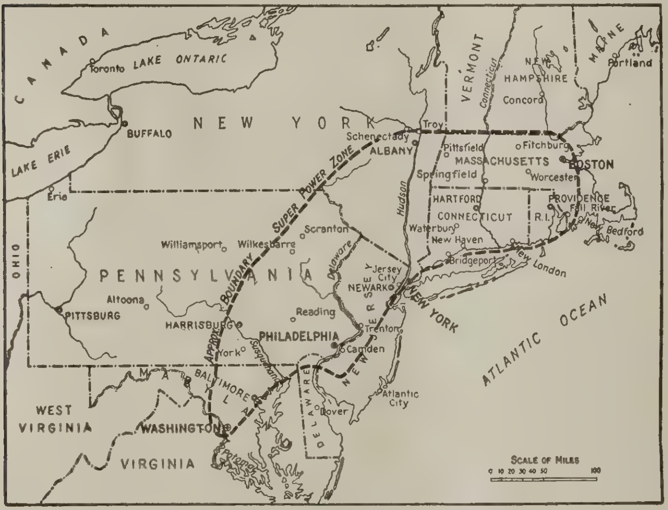
We landed them and poured water on them until they come to. Then we tried to find out how they did it, but all them poor dum guys know is that the steam was comin' out all over the water wagon and suddenly it busted and away they flew.

The yard master and me got sore because we were dead sure that they must have blown it up on purpose with dynamite, because it couldn't have blown up itself, as it was only juice with a fire under it.

Finally we shook hands and agreed that we had a great invention, and was going to make it work or our names wasn't yard master and Hinkey Dee.

Proposed Super-Power Zone

At the recent mid-winter convention of the American Institute of American Engineers held in New York, the entire morning session of February 19 was devoted to a discussion of the proposed super-power zone shown in the illustration. Undoubtedly the proposition is one of the most radical that has ever been given serious consideration by the Institute. Notwithstanding this fact, however, the proposed plan certainly has many features to recommend it. The scheme anticipates as closely as can be estimated conditions as they will be ten or fifteen years hence, and although it may appear as a tremendous undertaking there is no question but that it has received careful thought from many of the biggest industrial men in the section affected. Not only is an economcal supply of electric power planned for the industries of the northeast Atlantic seaboard, but for the railroads which traverse this territory as well.



Map Showing Approximate Super Power Zone

Briefly summarized, the super-power plant provides a means by which a present estimated machine capacity of 17,000,000 hp.—divided 10,000,000 for industrial purposes and 7,000,000 for the railroads—in a region between Boston and Washington and inland from the coast 100 to 150 miles, now operating with a load factor not exceeding 15 per cent, can be lifted to a load factor of greater than 50 per cent and possibly to 60 per cent, and a means by which, conservatively speaking, one ton of coal will do the work of two, and the railroads within the above zone, and those carrying coal into that zone, will be relieved of transporting one-half the amount of coal required for power and lighting purposes.

It is estimated that the present plant capacity of 17,000,000 hp. can be replaced by one of not greater than 5,500,000 hp. and that not less than 30,000,000 tons of coal per annum can be saved, which at $5 a ton represents $150,000,000 a year.

The plan offers immediate relief from the present intolerable congestion by automatically increasing rail capacity without increasing track mileage and reducing power equipment investment to a minimum. It is estimated that by the creation of an overhead common carrier system of power, the present cargo space now required for industrial coal will be cut in half; train equipment in all classes will have its service factor doubled, and the present steam power equipment, replaced by electrical equipment, can be transferred to other divisions where it is so badly needed.

The important facts in connection with the plant are as follows: *First,* the plant has the unanimous endorsement of Engineering Council, representing the American Institute of Electrical, Mechanical, Civil and Mining Engineers. *Second,* it has been presented and unanimously endorsed by (a) Western Massachusetts Engineering Association, (b) Bridgeport Chamber of Commerce, and (c) Connecticut Chamber of Commerce. *Third,* it is now in committee with the U. S. Chamber of Commerce and so far has found only favor in their consideration. *Fourth,* among the many prominent men who have discussed the matter are included United States senators, representatives, engineers, central station operators, railroad officials and financiers, all of whom have expressed the keenest interest in it. *Fifth,* an appropriation of $250,000 forms a part of the sundry civil bill to provide the money necessary to an investigation under the Department of the Interior.

These are the main facts to which many sundry details were added and discussed in the lengthy session of the convention which dealt with this matter. It is but perhaps natural that practically no opposition was presented when consideration is given to the fact that the men discussing it were electrical engineers and that the scheme itself represents one of the most colossal electrical engineering feats ever contemplated. Making due allowances for all optimism in connection with the plan, however, there is no question but that there are many powerful reasons why it should be advocated, and it will not be surprising if actual work is commenced on the project within the next few years.

THE CLEVELAND RAILWAYS COMPANY has taken out $10,110,000 insurance policy against "riot and civil commotion," paying a premium of $37,110. The policy covers 90 per cent of the company's line and is written by four western insurance companies.

Electrode Materials for Metallic Arc Welding*

Successful Lasting Welds Can Only Be Obtained by Using Proper Electrodes and Methods of Application

By E. Wanamaker and H. R. Pennington

ELECTRODES for arc welding generally consist of either carbon, graphite or metallic rods. In either case the electrode is the part manipulated by the operator and is one of the two parts between which the arc is formed.

Bare Metallic Electrodes, Sizes, and Chemical Composition

The metal electrode most commonly used at the present time consists of bare steel or ingot iron wire especially drawn and alloyed for welding purposes. The prime requisite for an electrode is that it should possess the necessary qualities which will make it possible to produce a sound homogeneous weld. To secure this result, the metal in passing from the electrode into the weld must be expelled in a uniform, finely divided state, thus permitting a close concentrated arc, which insures the proper state of fusion at the point on the work opposite the end of the electrode, so that when the expelled particles strike this fused spot they will unite and solidify with it.

If the metal is expelled in large globules the arc will not concentrate the heat sufficiently on the work to insure the proper state of fusion, in which case, when the globules strike the work they will adhere without fusion, which so often causes bad welds. It will also be found difficult to direct the metal where it is desired, and the deposited metal in the weld will be found more brittle, due to the increased oxidation, as a result of the lateral spreading of the arc. Any physical or chemical variation in electrode material must therefore be accomplished without detrimental effect upon the weldability requirements mentioned.

Electrode sizes.—The sizes most commonly used for electrodes are as follows:

Fractions of an Inch	Decimals of an Inch
1/16	0.0625
3/32	0.0938
⅛	0.1250
5/32	0.1563
3/16	0.1875
¼	0.2500

The use of wire or sheet metal gages as expressed in terms of B. & S., A. W. G., etc., to designate electrode diameters is confusing and therefore is not recommended. Electrode diameters should be expressed in mils (thousandths of an inch). The allowable tolerance plus or minus should not be greater than six mils. The importance of this will be appreciated by simply calling attention to the close relation of the current density to the electrode diameter, which, however, is not directly proportional to the diameter. Expressed in mils, the sizes most commonly used are 156 mils, 125 mils and 188 mils. The nature of the industry, of course, will determine the quantity of the different sizes to be used. On railroads and in shipyards the demand for the different sizes is in the same order as the sizes given above.

The length of the electrode commonly used is 14 inches. In some cases the material is purchased in coils and then cut into convenient lengths. This is not considered the best practice, however, as the small additional cost of the straight cut material will be more than offset by the cost of the time saved in handling by the operator.

The elements usually present in mild steel electrodes, upon which limitations are generally placed, are carbon, manganese, copper, silicon, phosphorus and sulphur. Little or no attention has been given to the gas content present in solution since the total does not usually exceed 0.1 per cent.

Carbon.—A limited carbon content is permitted in mild steel electrodes, mainly in order to include the average mild steel electrode material. A few welding men contended that a small per cent of carbon is desirable, as it improves the weldability of the material. This, however, has not been proved conclusively since electrode material of ingot iron practically free from carbon, but especially prepared, is in use, and its weldability proves to be as good as the electrodes containing a small per cent of carbon. Furthermore, as practically all carbon present in electrode material is lost in passing through the arc, its presence does not seem essential in welding electrodes for bare wire welding. On the other hand, the maximum carbon content usually permitted for bare electrodes is 0.18 per cent. If the carbon content is much higher than that amount, it has a bad effect upon the behavior of the arc unless the electrode has been specially treated.

Manganese.—The presence of this element up to 0.50 per cent is generally permitted. Above that amount, manganese, like carbon, has a detrimental effect upon the behavior of the arc. It also has a great affinity for oxygen, and when present in an electrode used for bare wire welding a very large per cent of it is burned out. It is claimed by some that a little manganese in the electrode adds to the tensile strength of the weld. On the other hand, the presence of manganese very much above 0.50 per cent causes brittleness in the weld, unless the metal is protected from the effects of the air.

Copper.—The inclusion of copper in an electrode is somewhat rare. It is unnecessary for good welding electrodes. However, copper has been used to some extent with the view of resisting corrosion, but there is no data to show to what extent this has been accomplished. The copper content is usually not specified in electrode material, and a copper-plated electrode used for the purpose of introducing copper into the weld, to prevent corrosion, or to protect the electrode itself from becoming rusty, is not successful. This type of electrode when used, will cause the arc to be erratic, and the copper will

---

*This is the eleventh and last article of the series on Electric Welding by E. Wanamaker, electrical engineer of the Rock Island Lines, and H. R. Pennington, supervisor of welding and electrical equipment, Rock Island Lines. Copyrighted, 1920, by the *Railway Electrical Engineer.*

be introduced into the weld in lumps. If copper electrodes are used the alloy must be homogeneous.

Silicon.—A maximum of 0.08 per cent silicon is usually permitted in electrodes. This limit is not difficult to meet in the basic process; ordinarily, however, the less silicon the better. It has been observed that an excess of silicon will increase the tendency of the metal to boil.

Phosphorus.—This element is undesirable in any quantity, however, 0.05 per cent as a maximum is permitted. Phosphorus causes "cold short" or brittleness.

Sulphur.—This element, like phosphorus, is undesirable, and is eliminated to the same extent. Sulphur causes "hot short" or brittleness, when the metal is red hot or hotter.

Ingot Iron Electrodes

There is in extensive commercial use an ingot iron electrode guaranteed to be 99.8 per cent pure iron. It surpasses the best Norway or Swedish iron. This material is specially drawn and treated for arc welding, and is found to work very satisfactorily.

Table I indicates that a common agreement has not yet been reached as to the chemical composition of bare wire electrodes for welding. This table shows the composition of some of the different electrodes in use:

TABLE I

CHEMICAL COMPOSITION OF METAL IN ELECTRODES

Trade name of electrode	Per cent carbon	Per cent manganese	Per cent phosphorus	Per cent sulphur	Per cent silicon	Per cent copper
Page steel, "Armco Iron"..	0.01	0.025	0.005	0.025	0.005	....
Norway	0.049	0.021	0.025	0.007	0.08	....
Central steel, "Sweedox"..	0.05	0.18	0.04	0.04	0.05	....
Siemund Wenzel Company.	0.10	0.30	0.05	0.05	Trace	....
Roebling Company	0.13	0.47	0.025	0.025	0.020	....
Wilson No. 6.............	0.15	0.60	0.04	0.04	Trace	0.25

An analysis of the metal deposited in a weld using two of the above electrodes is as shown in Table II.

TABLE II

CHEMICAL COMPOSITION OF METAL IN WELD

Trade name of electrode	Per cent carbon	Per cent manganese	Per cent phosphorus	Per cent sulphur	Per cent silicon
Roebling Company...	0.05	0.18	0.031	0.036	0.011
Norway	0.05	0.018	0.020	0.015	0.011

By referring to these tables it will be noted that practically all of the carbon, and approximately 70 per cent of the manganese is burned out. The fact that a little manganese passes through the arc into the weld may account for the claim that a manganese-bearing electrode will add to the tensile strength of the weld. On the other hand, the great tendency for this element to cause oxidation may offset any gain in tensile strength by an increase in brittleness. No data, however, are available to show the extent of the advantages brought about because of the presence of carbon or manganese up to 0.18 per cent carbon and 0.60 per cent manganese, either as regards the quality of the weld or the weldability of the electrode. It is known, however, that these elements are undesirable in amounts greater than this for bare electrode welding.

Most electrode specifications for bare wire welding are intended only to limit the carbon, manganese and other impurities. This fact is indicated in the electrode specification prepared by the welding committee of the Emergency Fleet Corporation, revised to December 20, 1918, as in Table III.

TABLE III

LIMIT OF CHEMICAL COMPOSITION FOR BARE WIRE ELECTRODES

Carbon	Not over 0.18 per cent
Manganese	Not over 0.55 per cent
Phosphorus	Not over 0.05 per cent
Sulphur	Not over 0.05 per cent
Silicon	Not over 0.08 per cent

State of Existence of Metal in Arc

In a previous article it was stated that the metal, when passing through the arc, according to all evidence at that time, was thought to be in the form of vapor and minute globules. This contention has since been supported by Mr. Hudson in the Journal of the American Welding Society. Mr. Hudson, after extensive research, states that "it would appear from observed facts that the metal deposited during metallic arc welding is transmitted, in part at least, in the form of minute particles at the rate of approximately 50 per second, and are projected from the electrode globule by the internal expansion of some vapor, possibly consisting partly of carbon monoxide gas. The expelled particles pass too rapidly through the arc to become vaporized and reach the plate in a fluid state." The rate of flow of the expelled particles referred to here was determined by holding an incandescent electrode, just removed from ordinary welding, over the rim of a revolving iron wheel. Furthermore, the arc tends to be established from which ever portion of the work or electrode volatilizes most rapidly. In this connection Mr. Hudson states that, "since the melting points of the different elements usually present in electrode materials, and other thermal constants of these elements and their compounds vary widely, and their chemical affinities are quite different it is to be expected that the constituents of an electrode subjected to a high temperature will change from solid to liquid or gaseous form successively and not at the same instant. Since the melting point of iron is higher than that of any other constituent of an electrode, with the exception of carbon, which combines rapidly with the oxygen (present in the air) at welding temperatures to form carbon monoxide; it is furthermore to be expected that in the welding process, the iron constituent will melt last.

"In metallic arc welding the temperature changes which take place differ to a marked degree from the changes incident to the usual methods of heating metals, to the extent that in welding a small mass of the electrode is subjected to a high temperature for a very short interval of time. The distinctive thermal feature of metallic arc welding is the sudden rise and fall of temperature in the metal transmitted to the work.

"Under these circumstances it may be seen that the melting of the iron is delayed by the heat absorbed by the other constituents of the electrode, and this fact, together with the limited time of application of high temperature, disproves the possibility that the iron is completely vaporized in the welding process."

The small spherical shell particles found about a weld are thought to be those particles which strike unfused metal on the work, and bounce along the surface. The gray dust seen floating in the air, and which collects around the weld, is thought to be, partly at least, the vapor carried out of the arc with these particles. These losses are accentuated with poor welding electrodes and may constitute a loss of 14 per cent of the electrode material consumed.

An examination of an electrode which does not work smoothly will usually show that the fused end is enlarged. This may be accounted for by the fact that most materials will show a marked increase in volume with an increase of temperature. An electrode fused by an excessive arc length will also show an enlargement at the end of the electrode.

From the foregoing it would seem that some elements alloyed with the iron or steel may be beneficial to the smooth working of an electrode, whereas others may not. At the present time there does not seem to be an electrode on the market containing a composition which will materially improve its working quality for bare wire welding.

An examination of the fused end of a smooth working electrode will present a cup-shaped appearance which would indicate that the center or core fused first and the shell last. An ideal electrode, therefore, would seem to be one having a high-fusing-point shell, graduated to a lower-melting-point core. Many methods have been employed to produce this effect, and while there are a number of treatments, usually confined to the surface, which work after a fashion, many of them are incidentally detrimental in other ways, such as increasing the slag inclusions in the weld, etc. A heat treatment method of drawing the electrode material so as to produce a shell having a high melting point and a core having a low melting point is employed at least by one concern. This seems to be an ideal method, as undesirable surface finishes are eliminated.

Physical Properties of Bare Wire Electrodes

The physical properties of electrode material are of extreme importance to its smooth working quality. The structure must be uniformly homogeneous, free from any structural imperfections such as oxides, pipes, seams, etc. The materials from which the wire is manufactured should be made by the best approved process.

At the present time about the only sure check the purchaser of electrodes has on their weldability is through actual test by an experienced operator, who shall demonstrate whether or not the material flows smoothly and in a reasonably uniform, finely divided state without any detrimental effects. The general use of coatings to make an inferior electrode flow smoothly is not considered good practice. In some cases poor welding material, termed wild iron, may not necessarily be inferior for such purposes when a coating is applied to quiet the arc and prevent sputtering. In most cases, however, this method is grossly misused by applying a coating to electrodes having excessive amounts of impurities, producing results detrimental to the weld.

From the foregoing it is evident that the electrode material for bare wire welding calls for either a practically pure iron electrode or for what is essentially a basic mild steel electrode with the impurities not exceeding those enumerated, and specially treated to meet the requirements. It is also evident that metal deposited with a bare electrode is practically a pure iron, and, as the fusion of metals under the highly oxidizing conditions of the welding process makes for brittleness, the ductility of the weld is greatly impaired. This latter deficiency has proved to be a serious obstacle in the application of the process to some structural and machine members subjected to repeated stress, such as bridge cord members, ship hulls, car axles, piston rods, etc.

The loss of the constituents of the electrode in bare wire welding prevents the use of certain alloys such as carbon, manganese, nickle, vanadium, etc., which are often added to secure strength and toughness, or to limit abrasive wear, but which are needed in many instances.

The tensile strength of welds made with bare electrodes is fairly satisfactory, as indicated by the many tests which have been conducted. In practically every case the average tensile strength was 50,000-lb. per sq. in. It is therefore evident that if the conditions under which welds are made are improved so as to secure more ductile metal in the weld and in some cases certain alloys as mentioned above, the scope of application of the welding process will be practically unlimited. The need of such improvements is indicated by the research and development work now being carried on in this country, as well as abroad.

Covered Electrodes for Arc Welding

A covered electrode, or flux covered, as it is sometimes called, is manufactured by the Quasi Arc Weltrode Company of England. This electrode is a metallic rod or wire with a covering of blue asbestos yarn, sometimes accompanied with other coatings of ferrous silicate, which, on fusing, is claimed to surround the metal with an inert gas, and prevents oxidation of the deposited metal. The yarn, it is claimed, is coated with sodium silicate, aluminum silicate or a similar compound to vary the fusing temperature of the asbestos. Other claims for this electrode are that the covering forms a fusible insulating coating around the metal core of sufficient thickness so that it may be held at an angle with the lower and resting on the work permitting the electrode to feed itself. In addition to the covering an aluminum wire is placed between it and the core for the purpose of preventing oxidation. When aluminum is present in a molten mass of iron, all of the aluminum will be oxidized first since aluminum has a greater affinity for oxygen than iron. The covered electrode is used extensively in England, mostly in connection with alternating current. When used with direct current the polarity is opposite to that ordinarily used for bare electrode welding; that is, the electrode is made the positive pole and the work the negative pole. An exhaustive series of tests have been made to investigate the claims of this electrode, but the results have not yet been published.

The cost of marketing the covered type of electrode seems to have limited its use in this country, also the somewhat different methods of application necessitated by its use and the removing of the heavy scale formed on the weld have given rise to some objections. The metal expelled from the electrode becomes extremely fluid, and remains in that state for a longer period than in the case of a bare electrode, due to the heavy slag formed over the weld. For this reason its use on work other than practically flat or down-hand welding is more or less difficult. Special electrodes are said to be furnished by this company for vertical and overhead weldings, also electrodes of special composition.

Test data to show the percentage of different alloy constituents that can be deposited into the weld by the covered electrode are not available. It has been demonstrated, however, that a weld made by a mild-steel-covered electrode is softer and more ductile than that made with a bare electrode. It is understood that the use of this covered electrode in ship construction in England has been approved by Lloyds Insurance Company.

Coated Electrode for Arc Welding

The term coated electrode has in the past been taken literally to refer to some form of a flux applied to the surface of the electrode, the function of which was to fuse with the electrode and act purely as a cleanser. As a matter of fact, however, there is at least one "coated" electrode, not necessarily flux coated, in commercial use which performs practically all of the functions claimed for the heavy "covered" electrode.

The authors of this series of articles on arc welding have been instrumental in developing this coated electrode in cooperation with the inventor. The coating is composed of a high-fusion-point material, or materials mixed with a suitable liquid, also of a high fusion point, which on drying serves as a binder to hold the material firmly to the surface of the electrode. The thickness of the coating, as compared to the covered electrode, is thin. The welding is performed in the same general way as with a bare electrode; that is, the arc is established and manipulated by the operator, and the coating is not used to separate the end of the electrode the proper distance from the work. The iron or mild-steel, coated electrode can be used in a vertical or horizontal position without difficulty. Welding in an overhead position requires more effort, but can be done with practice. Electrodes having high percentages of alloys are confined to practically down-hand welding, but generally this class of work is not required to be done in other positions.

The coating on the electrode fuses at practically the same rate as the electrode. Its function is to remain in a fluid condition about the particles or globules as they are rapidly expelled from the end of the electrode and arrange itself over the surface of the deposited metal, thus forming an almost continuous sheath or miniature crucible about the metal when undergoing the changes from a solid to a liquid or a gaseous state or vice-versa, excluding to a very large extent the surrounding air. Owing to the rapidity of the action or to the comparatively short interval of time that the metal is subjected to the high temperature of the arc, the constituents are not oxidized or burned to any great extent.

The effectiveness of the coating is evidenced by the fact that a high manganese and carbon content can be deposited in the weld. This is shown by the following test. The metal from an electrode containing 0.99 per cent carbon and 10.50 per cent manganese, with a coating as mentioned above, was deposited on a carbon steel rail by means of metallic arc welding. Direct current was used, with the work positive and the electrode negative. The appearance of the finished weld was perfect, being smooth and without gas holes or other imperfections. Further examination showed that the union was perfect. An analysis of the electrode and the deposited metal is shown in Table IV.

TABLE IV

Element	Electrode, per cent	Deposited metal, per cent
Carbon	0.99	0.71
Phosphorus	0.043	0.061
Sulphur	0.022	0.018
Manganese	10.51	10.19

The Brinnell hardness of the head of the rail was 154, and the average hardness of the deposited metal was 156. Due to the extreme toughness of the metal much trouble was experienced in pulverizing the deposit for analysis, many tools were broken, and when the sample was finally placed under a steam hammer in an effort to break it up, deep impressions were made in the hammer jaws.

Another test was conducted to determine the loss of constituents, using electrodes containing alloys in a milder form, and, with a very thin coating such as would permit welding in a vertical or horizontal position. The results are given in Table V.

TABLE V

Element	Electrode, per cent	Deposited metal, per cent
Carbon	0.18	0.15
Manganese	0.50	0.40
Phosphorus	0.012	0.012
Sulphur	0.032	0.032
Silicon	0.140	0.12
Nickle	2.97	2.08

Ordinary physical tests of welds made with the coated electrodes showed an increased ductility over those made with the same material without the coating. Other tests are being made to show more clearly the gain in ductility and the ability of the metal to withstand fatigue over that of bare electrode welds. These tests will be published when completed.

In the past, too much reliance has been placed upon figures of tensile strength. Many welds having fair tensile strength are, on the other hand, weak in transverse strength.

The superiority of coated electrode welds has been demonstrated in many instances in practice, where they have been in use for about eighteen months. Some of the applications have been referred to in a previous article. Incidental advantages have been noticed with the coated electrode that may be of interest. The lack of uniformity in the ordinary welding wire has always been a very serious matter, and even with material made in the most careful manner there will be found some electrodes that do not work well.

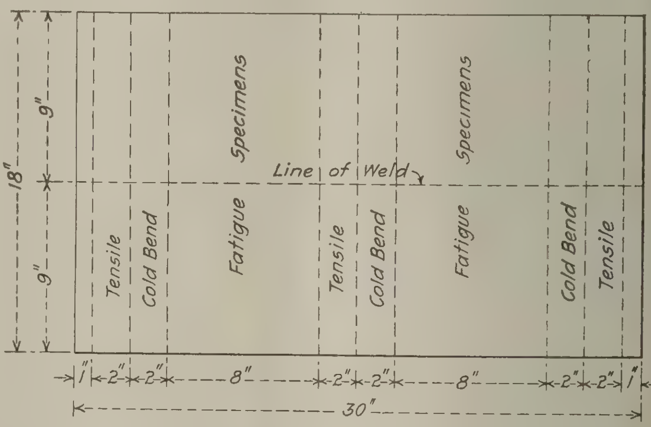


Fig. 1. Test Pieces for Tensile, Cold Bend and Fatigue Specimens.

When the electrodes are coated, imperfections in the wire may not be noticed; as a result, material is sometimes used which would otherwise be discarded. In this connection it should be understood that it is not intended to infer that an inferior electrode, especially in regards to the composition, can be made suitable for welding by coating it. As a matter of fact, it is just as important that coated electrodes be of the proper quality as it is for bare electrodes. It would be better to tolerate non-uniformity than to deposit metal with excessive constituents which are detrimental to the weld.

Operators using coated electrodes contend that the personal efforts of welding are somewhat minimized when the electrode is coated. Another apparent advantage of the coated electrode is that it provides a scale for the weld, which, when the coating has the right composition, has a greater co-efficient of contraction than the weld, so that when the weld cools somewhat the scale may be readily removed by light tapping with a hammer or chisel, thus exposing perfectly clean metal preparatory to adding the next layer of metal. The scale, by excluding the air, also prolongs the cooling so that the temperature of the weld is not reduced so rapidly. Consequently, the weld does not tend to become deficient in ductility to the same extent as welds made with bare electrodes.

The composition of the metal in the electrode, in relation to the part to be welded, is obviously a matter of importance. What this composition is to be can only be gaged by experiment and by wide experience. The complexities encountered in performing welding by the electric arc are so different than those of other methods of heating metals, that little data are available from which judgment may be based. In view of such conditions in devising tests to determine the quality of an electrode, many difficulties arise.

Procedure for Testing Electrodes for Arc Welding

A standard procedure of testing welds to determine the relative merits of different electrodes was drafted by the welding committee of the Emergency Fleet Corporation. Many elements enter into a test of this nature so that if the proper consideration is not given to each, they will greatly effect the accuracy of the ultimate result. An abstract of this specification with slight variations is as follows:

This specification describes a test of electrodes and not a combination of an electrode and of an apparatus (or welding equipment). The system used in making such tests may or may not prove to be of importance.

It is sought to minimize the influence of the individuality of the operator by requiring the test to include welds made by at least two operators. Only operators known to be competent should be used for such tests, and the approving and certifying of operators would be within the province of the purchaser, as well as the approving and certifying of systems.

Sample Electrodes.—Sample electrodes should be accompanied by affidavits giving the trade-name under which the electrode is marketed, together with certification that all electrodes bearing this trade-name will be substantially the same as the sample submitted, and such other information as is deemed necessary by the purchaser.

Plate Material.—Standard ½ in. ship-plate, as adopted by the American Society of Testing Materials, A 12-16 (page 98, A. S. T. M. Standards, 1918), are specified for the test.

The plates from which tensile, cold-bend and fatigue specimens are to be made shall be cut into pieces 9 in. by 30 in., as shown in Fig. 1.

The plates from which impact specimens are to be made shall be cut into pieces 30 in. by 30 in., as shown in Fig. 2.

Number of Test Welds.—One 30 in. weld for the tensile, cold-bend and fatique test shall be made, as indicated in Fig. 1.

Three 30 in. test welds for the impact test shall be made, as indicated in Fig. 2.

Preparation of Plates for Physical Test.—(a) Each test weld shall be machined down on both sides to about the surface of the plate.

(b) Specimens shall be cut from each test weld reserved for physical tests, as follows:

1. Three tensile specimens—these shall be machined to a uniform width of 1½ in. unless a weld of great strength makes it necessary to leave shoulders at the ends, in which case the standard A. S. T. M. test specimens for sheet iron and steel shall be prepared.
2. Three cold-bend specimens—these shall be machined to a uniform width of 1½ in.
3. Six fatique specimens—these shall be machined to about ½ in. diameter and 10 in. long. (The exact dimensions are to be determined by experiment.)

Physical Tests.—(a) TENSILE STRENGTH. The three specimens shall be tested in accordance with the practice recommended by the A. S. T. M. and shall include the determination of the tensile strength, yield point (by drop-of-beam method), reduction of area and total elongation after rupture in 2 in. and 8 in.

(b) COLD-BEND TEST. This test shall be made by placing the specimen on two ball-bearing rollers with the apex of the "V" upward and midway between the rollers and loaded at the center of the span thus formed by a cylindrical surface having a diameter of 1½ in. This surface shall bend the specimen downward between the rollers until a fracture appears on the lower side of the specimen. The loading shall then be stopped and the angle noted through which the specimen has been bent.

(c) FATIGUE TEST. Each of the six specimens shall be tested in a special rotating type of machine similar to that used by Lloyd's Register of Shipping. (Exact details to be determined by experiment.)

(d) IMPACT TEST. Each impact test specimen shall be placed on supports 18 in. high and 4½ ft. apart. A spherical weight of 500 lb. shall be allowed to fall freely through a distance of 10 ft., striking the weld, which shall be at the center of the span. The apex of the "V" shall be upward.

(e) TEST OF ORIGINAL PLATE. In order to establish the physical properties of the unwelded plate, tensile, cold-bend and fatigue tests shall be made on a sample selected at random from the pieces used for the test welds, but before such welds are made.

Chemical Analysis.—A chemical analysis shall be made of:
(a) The original plate in one test weld selected at random.
(b) The metal at the center of one test weld selected at random.

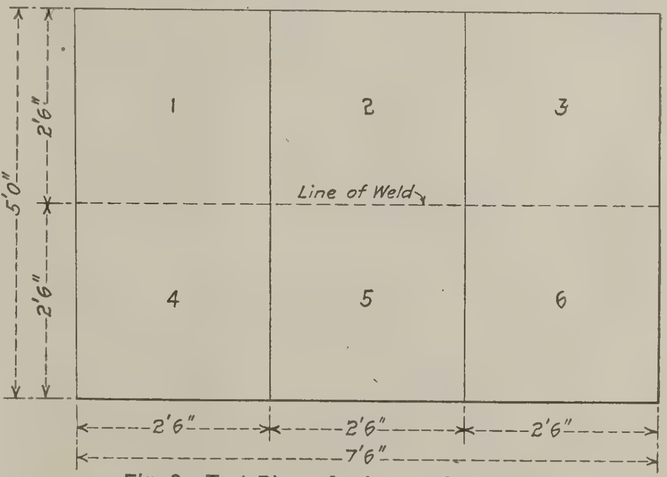


Fig. 2. Test Pieces for Impact Specimens

Photomicrographs.—Photomicrographs shall be made of one specimen weld selected at random, as follows:

At center of weld; at juncture of weld and original metal; in adjacent original metal; cross section of electrode; longitudinal section of electrode.

Any information on welding data which might be of importance should be recorded by the authorized representatives during the welding operations, such as identification mark of electrodes, description of electrode, sufficient description of welding apparatus for identification, name of operator, kind of current (i. e., d. c. or a. c.), open circuit voltage, arc current and voltage across arc, working quality of electrode, giving exact description of peculiarities noticed, if any, time per weld, weight of electrodes consumed, and any other information which would assist in determining the performance of the electrode or the quality of the weld.

A test, such as outlined, will involve some expense, but the resultant data and information revealed will constitute a wealth of information which will offset the expenditure many times. The adaptation of a standard form of procedure for testing welding electrodes will at least result in the elimination of much of the interior material now in existence, and it is hoped it will be an incentive to further the development of electrodes by the manufacturer. Uniformly, dependable electrodes have always been a serious obstacle in the progress of arc welding, and with improvements in this phase of the art great extensions in its application will result.

Cast Iron Electrodes for Arc Welding.—Due to the non-homogeneous structure of cast iron, and to the behavior of a material of this composition and the conditions of arc welding, its use has not been successful for metallic welding. Experiments by different parties are now under way, using cast iron rods high in silicon, ingot-iron high in silicon, bronzes, etc., which may result in more satisfactory results in cast iron welding.

Non-Ferrous Electrodes for Arc Welding.—Up to the present time no great amount of research has been made of non-ferrous electrodes. Certain aluminum-bronze alloy electrodes, low in zinc, are used with satisfactory results. The presence of more than 3 per cent of zinc is known to be unsatisfactory, as this element vaporizes at a much lower temperature than the other constituents with which it is alloyed. Some experiments that have been made indicate that non-ferrous electrodes properly made can be used, especially if they are coated or flux covered.

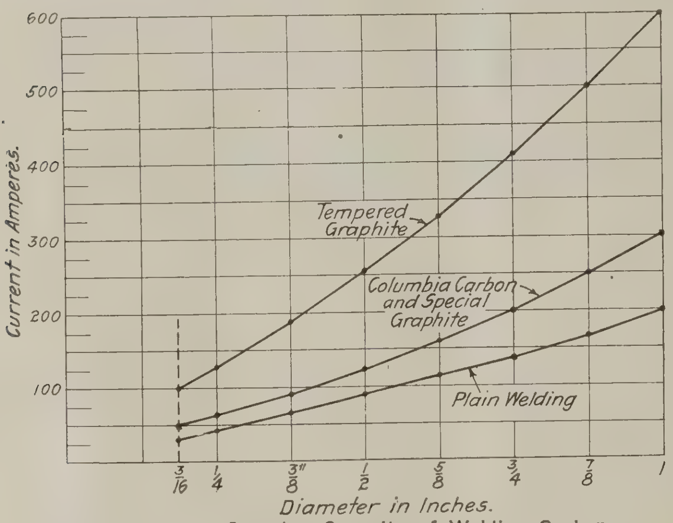


Fig. 3.—Curent Carrying Capacity of Welding Carbons

Carbon Electrodes for Arc Welding.—Carbon electrodes are furnished in various diameters, ranging from 3/16 in. to 2 in. Various compositions are furnished to vary the conductivity of the rod. They are also furnished plain and copper coated. The usual length is 12 in. and they are always pointed at the arc end, and in some cases the entire electrode is tapered. The approximate current carrying capacity for different sizes and grades of carbon electrodes is shown in Fig. 3, and may assist the user in selecting the proper size and grade of electrode to best suit the work at hand.

Henry Ford, president of Henry Ford & Son, Inc., Detroit, Mich., has designed a passenger car for street or interurban service to be driven by an internal combustion motor. It is expected that the car will be tried out on the Michigan Central tracks within the next 60 days.

Illinois Central's Chicago Terminal Negotiations Completed

With the issuing on February 20 of a government permit by Secretary of War Baker authorizing the Chicago Lake Front improvement project and the acceptance by the Illinois Central and the Michigan Central of the Illinois Central Terminal project ordinance, negotiations, which have been in progress ten years, were brought to a close. Work on the new terminal, it is expected, will begin early this spring. The railroads have filed a $1,000,000 bond with the city to insure the carrying out of its part of the plan which involves an expenditure of between $90,000,000 and $110,000,000. Charles H. Markham, president of the Illinois Central, has issued the following statement:

"We are prepared to begin at once. As soon as Congress returns the railroads to private control, we will make application to public authorities for authority to issue bonds. We want to complete our part of the plan as soon as possible."

The railroads' portion of the plan comprises a new terminal at Roosevelt road and Indiana avenue; electrification of the suburban service within seven years; electrification of the freight service north of Roosevelt road in ten years and of freight service south of Roosevelt road in five years; a new suburban station at Randolph street and a complete rehabilitation of the present equipment used in suburban service. The railroads have six months from February 21 before they will be required to begin work.

The signing of the bond by the railroads was considered of such importance to Chicagoans that elaborate ceremonies were held in the City Hall on February 18, the date of the signing. The signatures of C. H. Markham, president, and of B. A. Beck, assistant secretary, were attached to the bond of the Illinois Central, while that of the Michigan Central was signed by A. H. Smith as president. At the conclusion of the negotiations President Markham issued the following statement:

"The magnitude of the work involved in carrying on the improvements covered by the lake front ordinance, approved by the secretary of war, will require a separate organization. The work will be in charge of A. S. Baldwin, vice-president, who is already developing plans, estimates, etc., for an early commencement of the different stages of the work as required by the ordinance. The ordinance gives us two years for the development of plans and establishment of the roadbed and tracks in permanent position for electrification; the actual work of electrifying the tracks and the construction of new passenger stations to be entered upon at the close of that period.

"The first piece of construction required is a subway under Michigan avenue at Randolph street, for the benefit of pedestrians crossing Michigan avenue to reach the Randolph street suburban station. Plans for this subway are now in preparation, a permit for its construction will be obtained from the commissioner of public works, and, as soon as the weather permits thereafter, the actual construction will be started. This will be of material benefit to the public pending the reconstruction of the suburban passenger facilities in connection with the electrification of that service.

Alternating Current Theory and Practice

A Brief Practical Review of Basic Principles Prepared for Railroad Electrical Workers

By O. C. Callow

II.—The Alterating Current Generator

IT was stated in the preceding article that an electric generator is essentially a device for moving electric conductors past magnetic fields. There are two methods of obtaining this end; one is by placing conductors on an iron drum and rotating them so that they pass the face of the field poles which are stationary; the other method is to rotate the field poles past the conductors, which are mounted stationary on the inside of a circular iron frame. Both methods are used in practice, the two types being known respectively as revolving armature and revolving field machines. The principle of either of these types is the same and can be explained by considering the simple machine shown in Fig. 1, consisting of two field poles, one of north polarity and one of south, with an iron drum, free to revolve, mounted between the poles. On this drum are two conductors, *AB* and *CD*, upon opposite sides, having their ends *B* and *D* connected together, while the ends *A* and *C* are connected to two slip rings *E* and *F*, which are provided with some form of collector, through which the current generated in the conductors can be connected to the external circuit; that is, the circuit outside of the machine itself, to which the load would be connected.

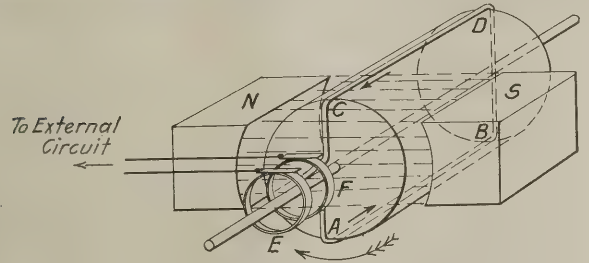


Fig. 1. Diagram Showing the Parts of a Simple Alternating Current Generator.

Magnetic lines of force are continually flowing from the *N* to the *S* pole. These lines will be thickest at the center of the poles and are indicated by broken lines in Fig. 1. The conductors *AB* and *CD* will cut these lines of force if the drum is rotated and a voltage will be generated in the conductors.

If the drum is rotated in a clockwise direction, the conductor *AB*, which is at the bottom, will commence to cut the lines of force and a small voltage will be generated in it. This voltage will increase as the drum rotates, until *AB* reaches the horizontal position. At this point it will cut the maximum number of lines of force, and therefore the generated voltage will be greatest. As the rotation is continued, conductor *AB* cuts less lines and the generated voltage falls off in consequence, until it reaches zero value when the conductor *AB* is in the top position and equally distant from the north and south poles. The conductor *AB* has now traveled half a revolution, the generated voltage has risen from zero to a maximum and fallen again to zero. As the conductor has been cutting lines of force flowing from the *north* pole, the voltage generated for the half revolution will be in one direction only. If the rotation is continued further, *AB* will commence to cut lines of force flowing into the *south* pole, which will cause the generated voltage to flow in the opposite direction to that which it was during the first half of the revolution. The voltage will again build up and reach its maximum value when *AB* is in the horizontal position and zero again when it reaches the bottom position between the north and south poles.

If the conductor *CD* be followed, it will be found that a voltage is generated in it corresponding to *AB*, commencing at zero when between the *N* and *S* poles in the top position, reaching a maximum in the horizontal position at the same instant that the voltage in *AB* reaches its maximum, and falling to zero in the bottom position. The only difference is that as *CD* is cutting lines of force flowing into the south pole during the first half of the revolution the generated voltage will flow in the opposite direction to the voltage in *AB*. Referring to Fig. 1, it will be found that during the first half-revolution the voltage in *AB* will be flowing away from the slip rings while the voltage in *CD* will flow towards the slip rings. It can readily be seen that if the ends *B* and *D* be connected together and the ends *A* and *C* to the slip rings and then continued through an external circuit, that a current will flow out of the slip ring *E* and back at *F* in the first half of the revolution, and out of *F* and back at *E* in the second half. When the drum of the machine in Fig. 1 has been rotated one revolution, the voltage and current generated will have started at zero, risen to a maximum in a quarter of a revolution, fallen to zero in half a revolution, changed its direction, and again built up to a maximum in three-quarters of a revolution, and have fallen again to zero at the completion of the revolution. In practice the machine will be said to have completed one *cycle* in one revolution of the drum.

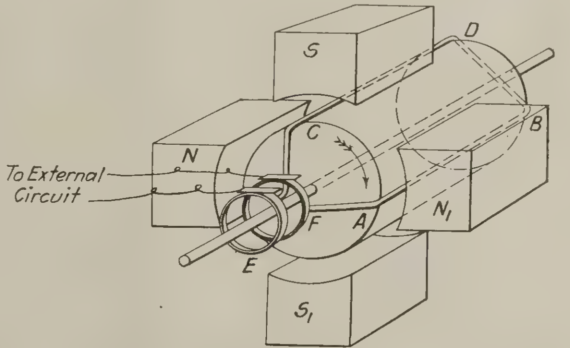


Fig. 2. A Simple Four-pole Alternating Current Generator

If we now consider a four-pole generator having two north and two south magnetic poles, as shown in Fig. 2, with two conductors *AB* and *CD* as before, it will be found that the generated voltage and current will complete two cycles for one revolution of the drum, one cycle while the conductor is passing the poles N and S and one while passing N_1 and S_1. In like manner a machine having eight poles will produce four cycles per revolution, or in other words, the cycles produced per revolution of the drum will always equal the number of pairs of poles on the machine. If the drum of the four-pole machine shown in Fig. 2 was rotated at a speed of 1,800 rev. per min., 3,600 cycles would be produced per minute, there being two pairs of poles and two cycles per revolution. In practice, when referring to the number of cycles of a machine or circuit, the cycles are always expressed in terms of "cycles per second." The above machine would therefore produce 3,600 cycles per minute which, divided by 60, would be 60 cycles per second. The term *frequency* is generally used when referring to the number of cycles produced by a machine. The machine shown in Fig. 2, rotating at 1,800 rev. per min., would be said to have a frequency of 60 cycles.

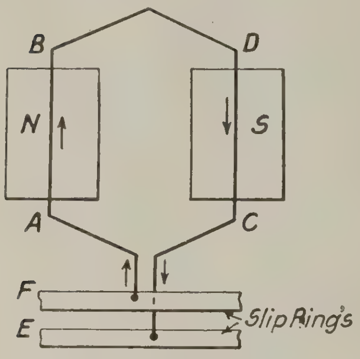


Fig. 3.

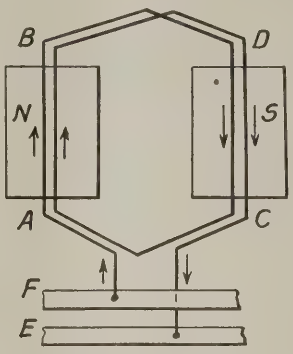


Fig. 4.

Fig. 3. Development of Two-pole Machine With One Coil Made Up of Two Conductors

Fig. 4. Same as Fig. 3 Except That Coil Has Four Conductors

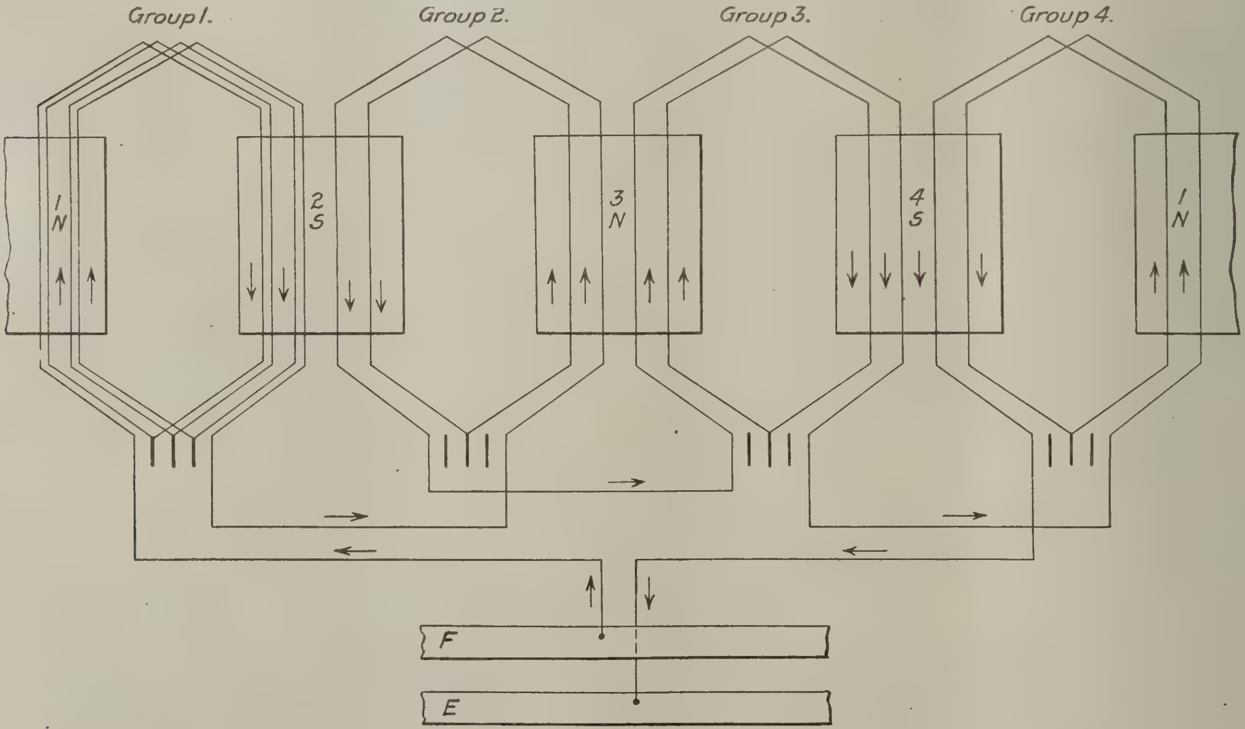


Fig. 6. A Developed View of a Four-Pole Generator Having Four Groups of Coils and Two Coils in a Group, Each Coil Being Made Up of Two Conductors

When it is desired to find the correct speed at which an alternating current generator should be run to give a certain frequency, the following formula can be used:

$$\text{Rev. Per Min.} = \frac{\text{cycles per second} \times 60}{\text{number of pairs of poles.}}$$

The simple two-pole generator shown in Fig. 1 has only one coil, made up of two conductors AB and CD. The voltage which these two conductors would have generated in them would be very small, even with a strong magnetic field. Some method, therefore, has to be devised to increase the generated voltage of the machine for commercial use. This is done by making each coil up into a number of conductors in series with one another. Fig. 3 shows a development of the two-pole machine with one coil made up of only two conductors. If this coil were made up of four conductors, as shown in Fig. 4,

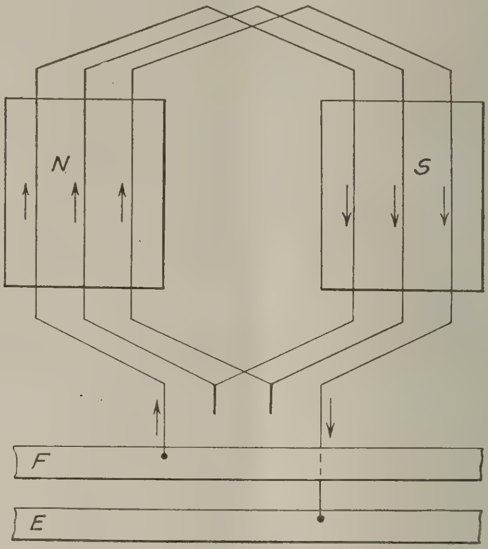


Fig. 5. Showing Conductors Arranged So That One Conductor of Each Coil Would Be Under a North Pole When the Other Conductor is Under a South Pole.

double the voltage would be generated. In practice, coils are wound with two, four, six, eight or more conductors, depending upon the size of the wire and the current which they have to carry. As the number of conductors which can be wound into one coil is limited, it is necessary to connect several coils in series with one another. These coils are known as a group. The coils in the group would be spaced out around the armature, so arranged that one conductor in each coil would be under the north pole and the other under the south pole, as in Fig. 5. All the conductors will have a voltage generated in them in the same direction and, being in series, their voltages will be additive. Fig. 6 represents a developed view of a four-pole generator having four groups of coils and two coils in a group, each coil being made up of two conductors. The coils in each group are in series and the groups themselves are connected in series in such a way that the generated voltage in all conductors under each respective magnetic pole will be in the same direction. In practice it is usual to place the coils in slots in the armature. These slots are made deep enough for two coils. The conductors of the first group in Fig. 6 would be placed under those of the second group in pole 2, and the conductors of group 2 in pole 3 would be under the conductors for group 3.

When the coils are arranged in this manner they are said to have a pitch equal to the pole pitch, meaning that if one side of a coil is under the center of one pole the other side of the same coil will be under the center of the next pole.

It has been stated previously that the voltage generated in a conductor will depend upon the strength of the magnetic field which the conductor cuts, and the rate of cutting this field. Furthermore, it was shown that the speed of a generator must be constant, as the frequency depends upon the speed. The only method, therefore, to adjust the voltage must be to control the strength of the magnetic field. This is done in practice by using coils around the magnetic poles. The coils are energized by a direct current supply, and the voltage of the supply is increased or decreased as required. By increasing this voltage a stronger magnetic field will be produced, the conductors cutting this stronger field will have more voltage generated in them.

Control Principles for Direct Current Motors

A Review of Controller Functions and Their Application to Various Kinds of Motor Drives.

By Gordon Fox

ONE of the greatest advantages of electric motor drive rests in the ease, flexibility and accuracy with which motion, imparted by a motor, may be controlled. It is necessary that a motor be suited, in characteristics, to the nature of the load demand. It is of equal importance that the proper control functions be employed to direct the application of motive effort to greatest advantage.

An electric controller may be described as a means for connecting a motor to its source of electric power, or for disconnecting it, also as a means for modifying electrical conditions to govern the performance of the motor.

The primary functions of a controller may be enumerated as follows:

To start and stop the motor, usually by connecting to and disconnecting from the source of power.

To govern the acceleration and deceleration of the motor and provide proper accelerating and decelerating conditions.

To control the direction of rotation.

To control the direction and amount of motor torque.

To control the speed of rotation.

To protect operator, machinery, motor and controller.

We will consider how these functions may be attained; first, with direct current motors; second, with alternating current motors.

To Start and Accelerate the Motor

Motors are designed with particular reference to running conditions. Controllers are depended upon to provide proper conditions during accelerating and decelerating periods. The ohmic resistance of the armature of a direct current motor is very low. When the motor is at rest, only the armature resistance is available to restrict the flow of current. If line voltage were impressed across an armature at rest, an excessive current would flow. To restrict the flow of current it is necessary to insert external resistance in series with the motor armature. This resistance is made of such a value that line voltage, impressed across armature and resistance in series, will cause a desired current to flow. Usually a current value of about 1½ times full load current is permitted. As the armature accelerates a voltage is generated within it due to the movement of its conductors through the field flux. The value of this voltage depends upon field strength and armature speed. The direction of this voltage is such as to oppose the impressed voltage. The net voltage available for driving current through the resistance of the armature circuit (including external resistance) is the difference between line volts and generated counter volts. It is evident that, as the counter voltage increases with the acceleration, the resistance of the armature circuit may be decreased by reduction in the amount of external resistance. As the armature approaches full speed its counter voltage becomes only slightly less than line voltage. All external resistance may then be eliminated, as the resistance of the armature circuit within the motor is then sufficient to restrict the flow of current resulting from the net voltage or difference between line volts and counter volts.

Small direct current motors, of fractional horsepower, sizes may be ordinarily accelerated from rest without the use of external resistance. This is due to their small size, limited current and quick acceleration. Series and compound motors are best suited to this duty, as the strong field causes the counter voltage to build up rapidly.

In a few special cases motors are accelerated from rest by building up the impressed voltage in unison with the counter voltage. This is feasible only when the motor takes its power from an individual generator, as in some main reversing drives of steel mills and mine hoist applications. In the general run of direct current starters and controllers an accelerating resistor is supplied to restrict the current during the starting period.

To Control the Direction of Rotation

Many motors operate continuously in a single direction. This direction is determined at the time of installation and there is no need for means in the controller to bring about reversal of rotation. Some motors operate ordinarily in a single direction, but are required occasionally to reverse. Some motors are called upon to operate in either direction at will. Some motors must reverse repeatedly according to a cycle required by the driven machine.

To reverse the direction of rotation of a direct current motor it is necessary to reverse the relative direction of flow of current in armature and fields. If the polarity of the fields be fixed, a reversal of armature current causes a reversal in direction of torque, due to current in armature conductors reacting upon field flux.

In either a shunt or series motor it is possible to reverse rotation by reversing either armature or field. If the fields of a compound wound motor be reversed, both series and shunt windings must be reversed in unison. It is therefore advisable and more common to reverse the armature connections to reverse rotation. In the case of interpole motors, the interpole winding must be considered as part of the armature circuit.

Reversal of armature current is ordinarily brought about by reversing armature connections at the controller. In a few special cases, as with reversing motors for main drives in steel mills, the armature current is reversed by reversing the polarity of the generator which feeds the motor armature.

To Control Direction and Amount of Motor Torque

As mentioned in previous paragraphs, the direction of torque or thrust in a motor armature depends upon relative direction of current flow in armature and fields. In the ordinary case, a motor revolves in the direction of its armature torque. There are exceptions to this condition.

If we "plug" a motor by reversing armature connections quickly while the motor is running, we will immediately reverse the direction of the torque, but will not reverse the direction of rotation until the reversed torque can overcome the inertia of the motor and driven machine and bring the motor to rest. For a brief period the direction of motor torque is opposite to its direction of rotation.

If we disconnect a motor armature from the line while the armature is rotating and short circuit this armature through a resistance, at the same time maintaining the field flux, the voltage generated in the armature by rotation past the fields will cause current to flow through the armature and resistance, short circuiting it. This current will, in turn, react upon the fields to produce a torque opposing the rotation, the motor acting as a generator, the resistance being the load. This process results in a decelerating torque, opposing rotation, and is commonly termed "dynamic braking."

In the case of crane hoists and some other "overhauling" loads we commonly have a condition where the motor torque may oppose the rotation. When we lower an empty crane hook we must drive it downwards against the friction of the hoisting gear. When we lower a heavy load, not only is the friction of the hoisting gear overcome but the load tends to speed up the motor, increasing its counter voltage above its impressed voltage. This causes the armature current flow to reverse, converting the motor into a generator with the torque opposing the rotation.

The amount of torque which a given motor develops depends directly upon the magnetic field strength and the amount of armature current. We can control the torque by controlling either of these factors. In the majority of cases we control the armature current. In accelerating a motor, for instance, we limit the armature current, not only to protect the motor, but also to protect the driven machine against the sudden application of too high torques. In dynamic braking we govern the armature current by adjustment of the resistance, which short circuits the armature. This controls the braking torque. In a crane hoist drive we control the restricting torque in lowering, by adjustment of armature current and field strength also, all by means of resistance in the armature and field circuits.

To Control Speed of Rotation

The speed of rotation of a direct current motor depends upon the fact that the motor endeavors to maintain definite relations between impressed armature volts and counter volts. It is possible to govern the motor speed either by controlling the impressed armature volts or by adjusting the field strength to affect the counter volts.

If circuits of different voltages are available, the armature may be supplied from more than one voltage. Other conditions being equal, the speed will be proportional to the impressed voltage. This is termed the multi-voltage system. It is not in extensive use.

The voltage of the generator supplying the motor armature may be varied. The motor speed will vary directly with the generator voltage, other conditions being equal. This method is possible only when the armature is supplied from an individual generator. It is used only for a few special applications.

The voltage impressed upon the armature may be adjusted by connecting resistance in series with the armature. The armature voltage is then reduced below line voltage by the amount of drop in the resistance. The resistance drop depends upon the amount of resistance and the current flowing through it. The latter depends, in turn, upon the load on the motor. There are two serious limitations to this so called "armature control" method of speed control. The first objection rests in the fact that, with a fixed resistance in circuit, the resistance drop varies with the motor load, and is greater, the heavier the load. As a consequence, the heavier the motor load the lower the impressed armature volts and the lower the speed. The speed regulation of the motor with varying loads is therefore very poor.

The second objection to "armature control" is its inefficiency. If the resistance drop is equal to half the line voltage, then half the power taken from the lines is delivered to the motor for conversion to mechanical work. The balance is dissipated as heat by the resistors. For any other ratio of voltages the loss is in proportion.

Armature control by resistance is used extensively for "manipulating" drives where the operation is intermittent, and is always under the control of an operator, as for street cars, cranes and many similar applications. It is also used with motors driving fans and blowers, where the load is constant and where the load decreases rapidly with reduction in speed, minimizing the resistance losses. It is to be noted, in this connection that, inasmuch as the voltage drop in the resistance depends upon both resistance value and motor load, it is necessary to adapt the resistance values according to the loads imposed upon the motor at the various speeds desired.

It should be evident that the range of speeds available through the "armature control" method is limited. For small reductions, down to 15 to 20 per cent below full speed, the operation is fairly satisfactory both in the matter of speed regulation and efficiency. Where greater reductions are desired the objections above noted are more pronounced. The maximum reduction commonly employed is about 50 per cent, except for intermittent duty under control of the operator.

Two or more motors may be supplied for driving one machine. The motors are ordinarily duplicates and are similarly connected to the machine. If the armatures of these motors be connected in parallel across the line each motor will assume a portion of the load, operating at its corresponding speed. If the two armatures be connected in series the voltage across each armature is reduced. If there is no external resistance in the armature circuit then each armature has one-half line voltage across its terminals. The result is that the required countervoltage is halved and the motor operates at half speed. A two-to-one speed range is thus seen to be possible with installations where two motors, mechanically connected, may be operated with their armatures connected either in series or in parallel. Many factors are involved in series and parallel operation of motors (these factors being considered more fully elsewhere).

Field Strength Methods

If the field strength of a motor be changed, the counter voltage generated at a given speed is immediately affected. Since the motor tends to maintain a balanced relation between impressed volts and counter volts it follows that a change in field strength brings about a change in speed sufficient to re-establish the balanced condition. Weakening the field of a motor tends to reduce the counter voltage and thus force the motor to speed up. Strengthening the field has the opposite effect.

The most common field control application is in the case of the adjustable speed motor. The motor is designed to operate at its minimum rated speed with the shunt fields connected across the line. The shunt fields are weakened by the insertion of resistance in series with them. At any given position of the field rheostat the motor speed remains nearly constant, regardless of the load. The range of speed control depends upon the design of the motor. Almost any well designed shunt interpole motor will permit an increase of 15 to 25 per cent above normal rated speed. Adjustable speed motors are standard for ranges up to 4 to 1. Special motors are sometimes built having as high as 6 to 1 ratio. In applying this method, care must be exercised to ascertain that the maximum safe speed of the driven machine is not exceeded. It is not always necessary to employ the full possible speed range of a given motor. The amount of resistance in the field rheostat can be arranged to give any range within the limits of the motors' rating.

With series motors it is not possible to adjust the field strength independently by means of series resistance. Two methods are employed in connection with series motors to vary the series field strength, namely, armature shunts and series field shunts. By placing a resistance around the armature of a series motor additional current is introduced into the series field. This additional current is relatively greatest when the motor is operating lightly loaded at good speeds. The effect is to reduce the speed of the motor, to restrict the speed at light loads and to give the motor a characteristic similar to that of a compound wound motor. The proportioning of the resistance depends upon the results desired. A limiting feature is the heating of the series field.

The armature shunt, as just described, is sometimes used to "slow down" a series motor from running speed to a low speed, as when approaching a limit of travel of the machine. Here the armature shunt acts both to strengthen the series field and to cause a braking effect upon the armature, similar to that discussed under "dynamic braking."

Armature shunts are commonly employed for "dynamic lowering" with crane hoist controllers. The shunt is so arranged as to practically convert the series field into a shunt field by placing it across the line in series with resistance. This arrangement limits the lowering speed of the hoist motion.

Armature shunts are also employed in connection with the hoist motion of cranes to give a very slow hoisting speed for handling machinery, etc. If a "shunt" or resistance be connected around the series field of a series motor it will divert from that field some of the current which it would otherwise normally carry. The effect is to weaken the field and increase the speed. This method is not extensively used, but is sometimes employed to secure a high speed operating point. It is sometimes employed for crane hoist controllers.

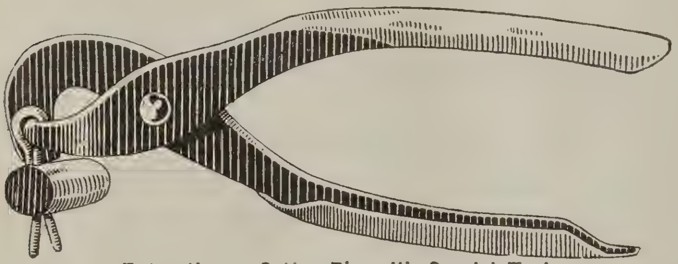
Motors are sometimes provided with two sets of shunt field coils. When both sets of fields are excited normal minimum motor speed results. When but one set of coils is excited, the field is weakened and a higher motor speed results. This practice is quite often applied in elevator service. Where local stops are made, both fields are in service. For express portions of the runs, high speed is attained by use of the single field.

The Japanese Government is erecting a powerful wireless station in the prefecture of Fukushima for the purpose of relieving congested communications between Japan and the United States.

PRACTICAL STUNTS

A Tool for Extracting Cotter Pins

The removing of cotter pins is often a difficult job, particularly when these are so located as not to be readily accessible. The tools most used for removing cotter pins are hammer and tommy bar, but there are many locations where a hammer cannot be used and the use of the tommy bar frequently damages the cotter pin to such an extent that it is worthless for further use.

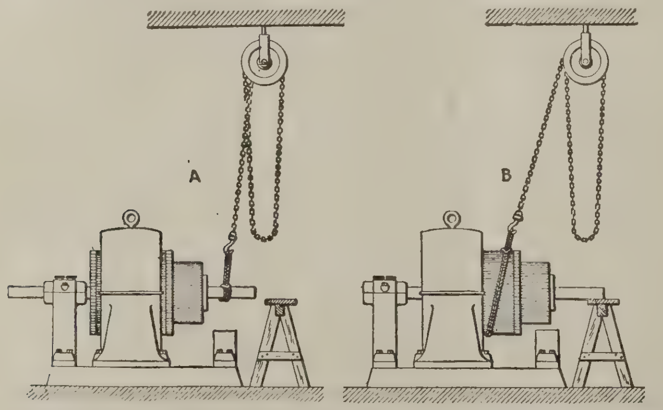


Extracting a Cotter Pin with Special Tool

The accompanying illustration shows a tool for removing cotter pins which has been given publicity by the *Scientific American*. The device is of the same size as an ordinary pair of pliers. One tong of the pliers engages the pin while the other uses all of the leverage exerted against the member through which the pin is inserted. As this leverage is four times as great as the actual force used, the pin comes out quickly and easily.

Method of Removing Generator Armature

If the frame of a generator from which the rotor is to be removed is not in two parts, considerable care must be taken in withdrawing the rotor so as not to injure the windings. This can be easily accomplished with a traveling crane, but if one is not available the work can be done with only slightly greater exertion by the aid of a chain tackle and a support arranged as shown.



Removing Armature with Stationary Block-and-Tackle Support

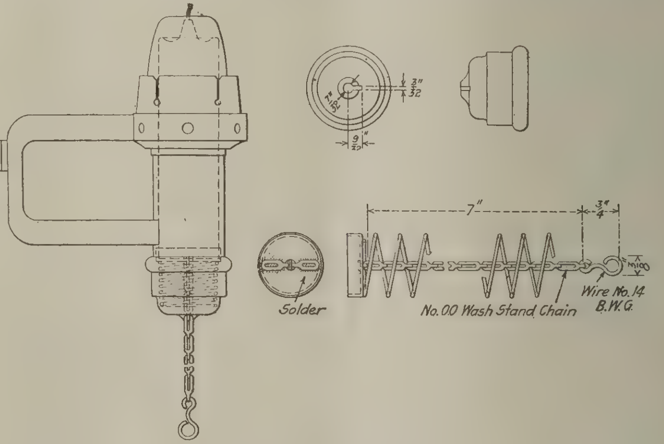
First a rope sling is arranged so as to support one end of the shaft during the removal of the bearing and other obstructing parts on that end. The tackle should, of course, be supported vertically over the shaft. The rotor may then be pulled out, taking up slack to keep the shaft in a horizontal position to prevent rubbing the rotor against the stator. A support arranged as illustrated facilitates the safe removal of the armature.

Care should be taken not to let the opposite end of the shaft drop out of its bearing before a sling is placed around the rotor to support it. After this is done the rotor can be swung clear of the frame and supported on wooden horses or lowered onto the floor. Once the block and tackle are in place, the operation is performed in very much the same manner as when a traveling crane is used.—*Electrical World.*

A Spring Check Chain for a Candle Lamp

By C. M. Tobias

For preventing waste and loss of candles in emergency candle light holders used in mail cars or in other cars where such emergency light is used, a novel arrangement has been devised by the car lighting department of the Cleveland, Cincinnati, Chicago & St. Louis at its Beach Grove shop near Indianapolis, Ind.



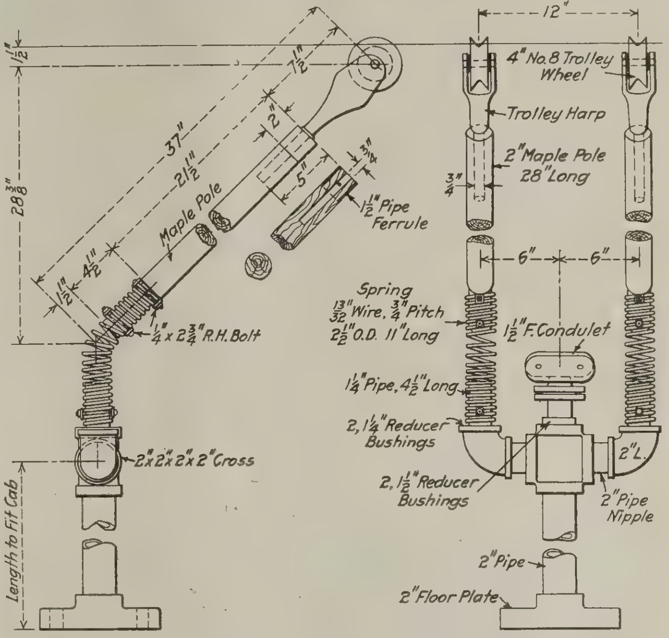
Details of Candle Lamp

The device embodies the application of a short piece of No. 00 washstand chain, one end of which is soldered to the metal cup which holds the base of the candle and which is attached to the upper end of the spring as shown in the illustration. The other end of the chain passes through a keyhole which is cut in the bottom cap of the candle holder. When the chain is pulled down the spring is compressed; in other words, the metal cap which supports the candle is drawn down into the bottom portion of the candle chamber of the bracket. By drawing the chain into the slot of the keyhole, the spring is held in the depressed or locked condition until the chain is released, which is only the case when the candle light is to be used. The reason for adapting a locking device for the spring was due to the fact that candles would gradually be forced out through the top of the holders due to the ordinary heat of the car which is sufficient to soften the candle thus permitting the tension of the spring to force the candle out of the holder. The final result would be the loss of a candle, either gone entirely or bent out of shape, so that further use would be out of the question. Actual experience reveals the fact that approximately two dozen candles per holder have been destroyed each year in this way. This spring checked chain may be applied to any of the candle holders in general use. The one shown in the illustration is the Dayton Manufacturing Company's candle lamp.

A Trolley for a Transfer Table

The illustrations show an overhead trolley arrangement in use on a transfer table at the Beech Grove Shops of the Cleveland, Cincinnati, Chicago & St. Louis near Indianapolis, Ind. This transfer table was operated for a number of years with the trolley wires supported on insulators, which were fastened to the side walls of the transfer table pit, but considerable difficulty was experienced with this arrangement. From a safety standpoint, the trolley wires introduced a hazardous situation and made conditions unsafe for employees who had occasion to work in or around the pit because of the possibility of coming in contact with the wires. Furthermore, it was hard to maintain the insulators which were attached to the side walls; and the transfer table occasionally would bind at the ends. This latter difficulty, although probably due to the bulging of the side walls, was to some extent aggravated by the weight of the trolley system. Because of these defects, the overhead trolley arrangement was installed and has since given perfect service. One feature of the new arrangement, which required careful planning, was the double trolley. Although the development of this trolley was based largely on designs which can be purchased from manufacturers, most of the parts in its assembly consist of stock materials. The trolley-arms are flexible because of the springs, and they will operate satisfactorily with both in the same direction, or with one in one direction and the other in the opposite direction. The trolley-wheels hold to the wires under all conditions.

The Transfer Table Showing the Trolley in Use



Details of Double Trolley for Overhead Wires

Using An Old Engine Oiler

A discarded long spout engineer's oil can can be made into a cup or quart measure by unsoldering the handle and removing the cone-shaped top and spout. If the work is done properly a thin flange will be left around the top edge of the cup. This can be turned back on the outside edge, which will leave a round, smooth finish, then the handle can be soldered on. Cups made as described have been used to good advantage for measuring oil, or for holding paint on small jobs.

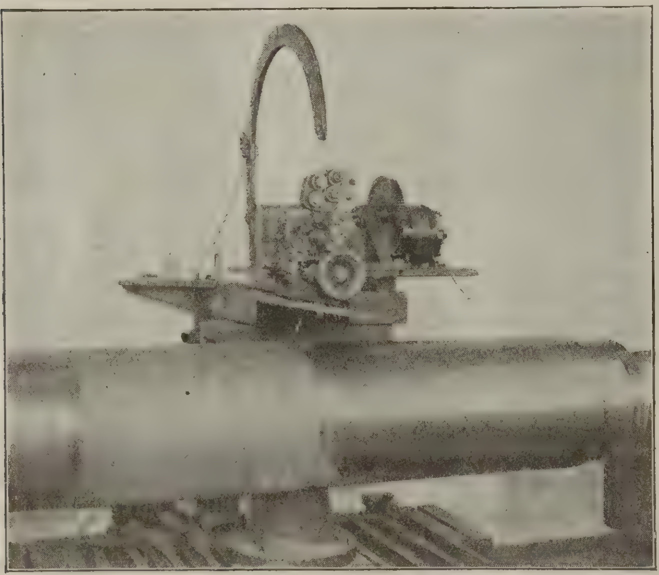
A Fire Resisting Cement

Frequently there arises an odd job here or there when it is desirable to use some kind of cement that possesses fire resisting qualities. The following formula will meet this condition and also has the advantage of hardening quickly. Two parts finely sifted unoxidized iron filings; one part, perfectly dry, finely powered loam. Knead the mixture with strong vinegar, into a homogeneous plastic mass to be used as soon as made.

NEW DEVICES

An Automatic Arc Welding Machine

Automatic arc welding is now accomplished by a new device perfected by the General Electric Company, and soon to be put on the market. It is known as the Automatic Arc Welder. This welder is for use with the regular welding set, is designed to take the place of the hand controlled electrode. It consists of a pair of rollers, called feed rolls, driven by a small direct current motor, which draw in, and deliver to the arc a steady supply of wire, and at the same time automatically maintain the best working distance. The whole is controlled from a small panel.



The Automatic Arc Welding Machine Rebuilding a Shaft

The welding head is held by a suitable support with a certain amount of hand regulated adjustment, and consists of a steel body carrying feed rolls and straightening rolls which are both adjustable for various sizes of wire. The arm is supported on a gear box, together with the motor. This box contains gears which give three gear ratios, thus extending the range of the device while allowing the motor to operate at its most favorable speed.

The control panel carries an ammeter and voltmeter for the welding circuit, as well as rheostats, a control relay, and the contactors and switches for the feed motor. It is possible to start and stop the equipment from the work by a pendant push button, but adjustment of the feed conditions must be made from the panel.

The adjustment for arc conditions by regulation of the speed of the feed motor, as the arc voltage varies, is taken care of by the panel equipment. The result is a practically steady arc, which is greatly superior in smoothness of operation to any hand controlled arc, consequently increasing the speed of the welding.

The whole apparatus is mounted on a base which can be bolted to any form of support. Thus a great variety of working conditions can be met, but provision must be made for carrying the arc at uniform speed along the weld. For instance, for straight seams, a lathe or planer bed may be used, and for circular ones, a lathe or boring mill. However, the local conditions will dictate the method to be followed.

The device is especially valuable where a large amount of routine welding is to be done, since it is capable of from two to six times the speed possible to skilled operators and gives a uniform weld of improved quality. It is adaptable to welding seams of tanks and plates, rebuilding worn or inaccurately turned shafts, rebuilding worn treads and flanges of wheels, and many other kinds of work.

Two New Enclosed Starters for Small Direct Current Motors

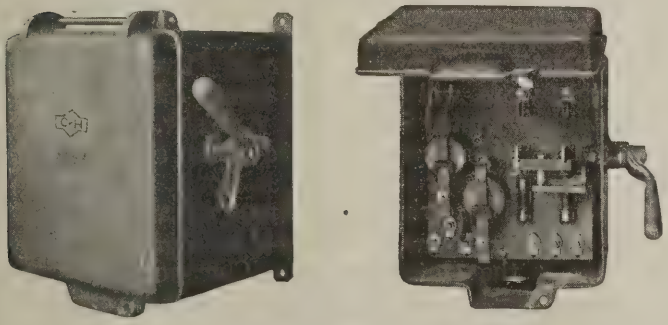
It is generally conceded that unprotected power terminals are as much a source of danger as unguarded gears and machines; hence, as a safety measure, electrical societies are encouraging the complete enclosing of motor starters to protect workmen from coming in contact with live parts. Although safety conditions are primarily the cause of the demand for enclosed starters, some installations require the enclosed type as a means of keeping the contact making parts clean and the starter in good operating condition.

The latest additions to the line of enclosed starters manufactured by the Cutler-Hammer Mfg. Co., of Milwaukee and New York, are known as Bulletins 2111 and 6193. The former consists of the familiar type of direct-current face plate starter enclosed in a sheet metal case having an external lever which engages the movable arm of the starter. The external, or operating lever is insulated from the revolving contact arm by a block of molded insulation. A pointer on the lever and legends stamped on the cover indicate to the workman whether the starter is "off" or "on." In the smallest size of starter a knob of black insulating composition is provided in place of the operating lever. A low-voltage release coil in series with the shunt field protects the motor in case of voltage failure or if the field should be opened while the motor is running. The armature resistor is completely enclosed in the starter case, which is kept well ventilated by a flue in the top.

Bulletin 2111 Without Cover and With Cover

With the exception of the enclosed feature, the Bulletin 2111 starter is similar to the latest design open-face type of C-H standard starter, which can be changed to the enclosed starter descibed above in the few minutes required to change the operating lever and put on the enclosing case. Both the enclosed and open type starters are used with d.c. motors up to 50 h.p., operating at 115, 230 and 500 volts.

Bulletin 6193 is an automatic motor starter panel of the counter e.m.f. type completely enclosed in a cast iron case with a hinged cover. The automatic feature is obtained by an accelerating contactor which closes when the motor attains about three-fourths full speed, and automatically shunts out the starting resistor. A magnetic main line contactor mounted on the panel allows remote control from two push button switches of the momentary contact type. The operation of the contactors in conjunction with the push button switches is as follows: Pressing the "run" button closes the magnetic main line switch, thereby starting the motor with the armature resistor in circuit. The motor accelerates until it reaches about three-fourths normal speed, when the resistor is automatically cut out of circuit by the closing of the accelerating contactor, the operating coil of which is connected across the motor leads and is energized by the counter e.m.f. of the armature. The motor is stopped by pressing the "stop" button, or by voltage failure, both of which cause the main line contactor to drop out. A common snap switch, a float switch or a pressure regulator can also be used for the remote control of the motor. When remote control is not desired the magnetic main line contactor is omitted, and the motor is started by a fused knife switch mounted on the panel with an operating handle outside of the case. The handle can be locked in the open position to prevent unauthorized operation. Interlocks prevent lifting the cover while the switch is closed or throwing the switch with the cover opened. When the knife switch is used, low voltage release is inherent in the accelerating contactor, which will again close after the voltage returns and the motor has accelerated to three-fourths normal speed, provided the knife switch is still in the closed position. The cast iron enclosing case is arranged for conduit wiring and can be mounted on a wall or any flat surface. This starter is for use with small d.c. motors not rated over 2 hp. at 115 volts or 3 hp. at 230 volts.



Two Views of Bulletin 6193

With many factories and shops today equipped throughout with individual motor drives, the field of application of these starters is broad. They give satisfactory service with motors starting with normal load and operating with unvarying voltage, such as those driving fans, blowers, pumps, lathes, drills and small motor-generator sets for arc welding. By employing a separate field rheostat the Bulletin 6193 starter may be used for the control of motors operating at variable speeds above normal.

Vapor Proof Fittings

Three new vapor-proof fittings recently placed on the market by the Adapti Company, Cleveland, Ohio, are shown in the accompanying illustrations. These fittings are especially designed for use in chemical plants, oil refineries, tanneries, paper and pulp mills, subways and tunnels, and in marine installations. In order to secure flexibility of installation in a rigid fitting the maker taps four holes in the box and plugs those not intended for immediate use. All plugs are inserted in the box before it is japanned or galvanized so that a vapor-proof joint at every plug is obtained. The advantage claimed for these fittings is that their construction makes extensions and changes possible at any time at a minimum expense without tearing out any part of the existing equipment.

High Tension Line Tapping Machine Attachment

An attachment for a high-tension line tapping machine to enable the tapping machine to be used for tying a new insulator back onto the line after replacement, without shutting off the current, is being made by the Bush Electric Company, Cleveland, Ohio. To use this machine a tie wire is attached to an insulator and the two ends of the wire are left sticking up so that they will be on opposite sides of the line wire when it is lowered down onto the insulator. The tapping machine with the attachment is then slipped over the line wire on one side of the insulator and the loose end of the tie wire is picked up by the device and closely wound around the line wire in the same manner as it would be if wound by hand. This operation is repeated on the other side of the insulator.

General News Section

The Cutler-Hammer Manufacturing Company, of Milwaukee, Wis., has recently revised and reprinted two of its standard descriptive booklets known as Booklet "A" and Booklet "S." The former describes C-H motor-operated brakes for alternating current service; the latter describes and illustrates the C-H magnetic separator.

Roller-Smith Company, New York, recently issued its four-page bulletin No. 420, illustrating and describing a line of small alternating current meters. The growing need of a. c. instruments of smaller sizes led to the development of the "Junior" and the 4-in. "Imp" types which exactly correspond to similar d. c. meters manufactured by the same company.

F. S. Montgomery, who for the past six years has been advertising manager for the National Metal Molding Company, Pittsburgh, Pa., and who prior to that was, for several years, district manager of the Atlanta office of the same company, resigned recently to become associated with the Ivan B. Nordhem Company, New York City. The business of the Nordhem company is outdoor advertising.

The Detroit Sales Office of the Standard Underground Cable Company which for several years has been a sub-office of the Chicago office has been made a full branch office with R. E. Green in charge. Mr. Green has been in charge of the Detroit office since it was first opened. He has been connected with the Standard Underground Cable Co. since 1909 as salesman and is well known in this territory.

Sleeping car porters on the Canadian Pacific are to have their pay advanced five and ten dollars a month, the increases to date from December 16, in accordance with the recommendation of a board of conciliation which has just made a report. The rates are to be, for the first year $75; for the second year $80 and for the third year $85 a month. On observation cars, compartment cars and buffet cars the rates will be $92.50 a month. About 500 porters will receive the benefit of this advance.

The American Association of Engineers will hold its second annual railroad conference at the Congress Hotel, Chicago, on March 15. W. W. K. Sparrow, chief engineer of the Chicago, Milwaukee & St. Paul Railway Company, will act as chairman of the morning session of the conference. Among the topics which will be discussed are: the Association's work in the railroad field during 1919; plans for future railroad work; the organization and function of railroad sections; and the Association's railroad salary schedule.

Harvey Hubbell, Inc., Bridgeport, Conn., announces that in the suits of Harvey Hubbell, Inc., vs. the General Electric Co. and Bryant Electric Co. for infringement of Hubbell Patents Nos. 774250 and 774251, covering attachment plugs, decisions have been filed by Judge Thomas in the United States District Court upholding the Hubbell Patents and finding infringement thereof. In the suit of the Bryant Electric Company vs. Harvey Hubbell, Inc., charging infringement of the Burton Patent, a decision has been filed by Judge Thomas of the United States District Court, finding the Burton Patent invalid.

The Lakewood Engineering Company of Cleveland, Ohio, has recently opened a district office at 6 Beacon street, Boston, Mass., for the sale of its industrial equipment lines. This office is in charge of **William Waring,** who, for the last two years, has been connected with the Philadelphia and Washington offices of the company. The new office is prepared to furnish the regular Lakewood industrial haulage service to New England manufacturers. The Lakewood construction equipment lines are handled in New England by the Waldo Brothers & Bond Company, 181 Congress street, Boston, Mass., which is a combination recently formed by the consolidation of the Waldo Brothers, Inc., and the Harold L. Bond Company. The latter have handled the Lakewood lines for several years.

The National Carbon Company, Inc., Cleveland, Ohio, recently established a railroad sales department to handle the sale of all commodities which that company manufactures for use on steam railroads. J. M. Spangler, sales engineer with headquarters at St. Louis, Mo., has been transferred to Cleveland to supervise railroad sales in central, western and southwestern United States. C. S. Pflasterer, who has charge of soda cell business for the National Carbon Company at Cleveland for the past eight years, will supervise railroad sales in eastern and southern United States. W. A. Sisler, who for the past ten years has been employed in the signal department of the Missouri Pacific at St. Louis, succeeds Mr. Spangler in that territory as railroad sales engineer.

The Western Railway Club held its regular monthly meeting at the Hotel Sherman, Chicago, on February 16, at which a paper on electric arc welding, illustrated by lantern slides, was presented by W. B. Brady commercial electrical engineer of the General Electric Company, Chicago. This paper was substituted for one on "The Railroad Administration Wage Agreement with the Railway Employees' Department of the American Federation of Labor," which was to have been presented by Frank McManamy, assistant director of the mechanical department of the Division of Operation of the United States Railroad Administration. Mr. McManamy was unavoidably detained in Washington and it is expected that he will present his paper at the April or the May meeting of the club.

A New Sudan Railway.—A Cairo correspondent of the Times, London, is authority for the statement that it is proposed to extend the railway from Suakin to

Tokar, thus tapping an important cotton growing district. Tokar lies about 50 miles south of Suakin, a few miles from the Red Sea, its port being Trinkatat. The region was the scene of much fighting during the campaigns against the Mahdi.

Prompted by the need of and demand for a better understanding of the fundamental soundness of the American Constitutional Government on the part of the general public as well as for a clearer apprehension of the fallacious, and in some cases, vicious attacks upon this government, several influential business men of Milwaukee have formed the American Constitutional League, of which Frank R. Bacon, President of the Cutler-Harmer Mfg. Company of Wilwaukee, Wisconsin, has been elected chairman. The league is non-sectarian and non-racial in membership and purpose. Its activities will be confined solely to Americanization work, which will embrace all forms of education and publicity in favor of Americanism and in opposition to all radical doctrines which have for their purpose the overthrow of our existing form of representative government and our present social and industrial order.

Committee on Steam Railroad Electrification

President R. H. Ballard reports that Frank M. Kerr, vice-president and general manager of the Montana Power Company, has accepted the chairmanship of the Committee on Steam Railroad Electrification.

The Montana Power Company, of which Mr. Kerr is the operating executive, is now furnishing the power supply for the operation of 657 miles of the Chicago, Milwaukee and St. Paul Railroad in Montana and the Pacific Northwest, and consequently he is in a position to speak with authority on the subject of railroad electrification from a practical standpoint.

R. Beeuwkes, electrical engineer of the Chicago, Milwaukee and St. Paul Railroad, will act with Mr. Kerr on this committee, and the additional members will be from other power companies, manufacturers, and banking institutions, so that every phase of this great subject will be intelligently handled in the report of the committee which will be submitted at the Pasadena convention next May.

Wireless Telephone Spans 1500 Miles

At a meeting of the New York Electrical Society held in the Engineering Societies Building, New York, on February 26, an interesting lecture on the subject "Some Long-distance Radio Telephone Tests" was delivered by Robert F. Gowen, engineer of the De Forest Radio company. Mr. Gowen told of tests in which he had spoken 1,500 miles with a wireless telephone set using less than one-half a kilowatt of energy. The results he had secured he said were obtained with a small aerial and low wave length much the same as used by many amateur wireless stations. The accomplishment, he pointed out, established a world's record for the transmission of human speech by a portable wireless telephone outfit. The point at which Mr. Gowen's transmitter was located was Ossining, N. Y. He later received letters from wireless operators from points as far away as North Dakota and South Carolina, in which they told of having heard Mr. Gowen's voice with remarkable distinctness.

PERSONALS

B. F. O'Rourke has been appointed to the newly created position of terminal electrician on the Chicago, Rock Island & Pacific with headquarters at McFarland, Kan.

C. A. Pinyerd, supervisor at the Chicago office of the Safety Car Heating & Lighting Co., New York City, has been appointed sales representative with the same headquarters.

F. S. Wallace, electrical repairman of the Pullman Car Lines at Augusta, Ga., has been appointed foreman—electrician's assistant of that company, on the Pennsylvania Railroad, with headquarters at New York, succeeding **M. J. Wickham,** deceased. **A. T. Terrace,** electrical repairman at Boston, Mass., has been transferred to Augusta, Ga., to succeed Mr. Wallace, and **C. E. McMakin** has been appointed electrical repairman at Boston.

Several positions for electricians, first class, have been created on the St. Louis-San Francisco Railroad and the company announces the following appointments: **Henry J. Baer** and **Ottis H. Ross,** with headquarters at Monett, Mo.; **Harry H. Finch,** south roundhouse at Springfield, Mo.; **Joseph A. Condon** and **Hugh B. Hope,** St. Louis, Mo.; **Spurgeon Carter** and **Ward E. Puckett,** located at Memphis, Tenn.; **Mack L. Londagin,** West Tulsa, Okla.; **Glenn B. Salmons,** Sapulpa, Okla.; **John R. Frank,** Fort Scott, Kan.; **M. L. Sexton,** located at Fort Smith, Ark.; **C. B. Franklin** at Kansas City, Mo., and **C. W. Duerr, William Rutledge** and **Byron C. Huffstutter,** located at Birmingham, Ala. **Maurice T. Fors,** electrician, first class, located at Springfield, Mo., has been transferred to Sapulpa, Okla. **Edward N. Hughes,** electrician at Springfield, Mo., has been appointed electrician, first class, at Sapulpa, Ohla; **Marcus C. Raper,** helper apprentice at the north shop, Springfield, Mo., has been promoted to electrician, first class, at Fort Scott, Kan.; **George W. Weitnauer,** helper apprentice at the south shop, Springfield, Mo., has been promoted to electrician, first class, at the north shop, in that city; **William R. Breshears,** helper apprentice at the north roundhouse, Springfield, Mo., appointed electrician, first class, at the south roundhouse, Springfield. **John J. Sullens,** electrician on the Chicago, Burlington & Quincy at Chicago, Ill., has entered the employ of this company as electrician, first class, at Kansas City, Mo. **Luther L. Londagin,** lineman in the telegraph department at Springfield, Mo., has been appointed electrician, first class in the electrical department at Fort Smith, Ark. **Clarence L. Cowan,** axle light maintainer at Memphis, Tenn., has been made electrician first class, at the same place, succeeding **Noah O. Baty,** deceased. **Perry E. Moore** succeeds Mr. Cowan as axle light maintainer. **Charles G. Moon,** stock clerk of the store department, at Springfield, Mo., has been made electrician apprentice at Memphis, Tenn.; **C. W. Shaw,** lineman in the telegraph department at Springfield, Mo., has been made electrician apprentice in the electrical department at Kansas City, Mo. **Frank L. Frear,** helper at Sapulpa, Okla., now apprentice at Monett, Mo., **Orvel Cooper,** electrician helper at Monett, Mo., transferred in the same capacity to Fort Scott, Kan. **William F. Giltner,** electrician helper in the north shop at Springfield, Mo., transferred to the south shop. **Ellis M. Harrison** has been made electrician apprentice at the south roundhouse in Springfield, Mo., **Elsa Wiley** made electrician helper at Sapulpa, Okla., and **Roy F. Robberson,** crane operator at Springfield, Mo., has been made electrician helper apprentice at Sherman, Texas, and **T. A. Wakefield** succeeds Mr. Robberson.

O. B. Hodgson

Oliver B. Hodgson, lately connected with the Stone-Franklin Company in the capacity of electrical engineer, died at his home in New York on February 8, 1920, after a lingering illness. Mr. Hodgson was born in New York on November 20, 1887. He received his early education in the public schools, later attending Pratt Institute in Brooklyn, N. Y., at which place he took the course in electrical engineering, graduating in 1908. The following year Mr. Hodgson entered the employ of the New York Central railroad. His first work with this company was the inspection of transmission lines and third rail construction. Afterwards he became inspector of multiple unit car equipments and still later was assigned the duties of making special tests of electrical equipment for the engineering department. Subsequently, Mr. Hodgson specialized in axle lighting apparatus. He left the New York Central in 1917 to become electrical engineer with the Stone-Franklin Company, which position he held until September, 1919, when he resigned on account of poor health.

Harold M. Davis, manager of the advertising department of the Sprague Electric Works, General Electric Company, died on February 9, 1920, at his home in Brooklyn, N. Y., after a lingering illness of about three weeks. For the past two or three years his general health was very poor, and the end was not altogether unexpected by his many personal friends, as well as his business associates. Mr. Davis was born on August 26, 1860, in Jerseyville, Ill. His early boyhood was spent in Kansas, where he received a public school education, later finishing at the St. Louis high school. For several years after graduating from high school he worked in the office of a lead and oil factory, from which place he resigned to accept the appointment of chief clerk of the St. Louis U. S. Assay Office, receiving the appointment from President Chester A. Arthur. The government position, however, was too slow and uncertain for an ambitious boy, and he came to New York to study architecture. The financial panic of 1893 offered him a chance to enter the advertising profession, in which he had some experience while in St. Louis. For four years he was advertising manager of a trade paper in New York, afterwards being connected with an advertising agency, thus broadening his experience and fitting him for his final position as manager of the advertising department of the Sprague Electric Works of the General Electric Company, which he obtained in December, 1899. His ability as a writer and a designer gave him an advantage over other solicitors which publishers were quick to recognize and which resulted in the formation in leading publishing plants of what is now known as the Service department.

TRADE PUBLICATIONS

The Trumbull Electric Manufacturing Company, Plainville, Conn., has just issued its new catalogue No. 12 illustrating a complete line of knife switches, safety switches and other wiring devices. The catalogue consists of 164 pages, size 8 in. by 10½ in. It is printed in three colors, yellow, red and black. Although it is not made in the regular loose leaf form, it is so bound that by removing the fastening clips additional pages can be inserted.

Typical installations of Edison equipped railway storage battery cars are shown in Bulletin 106, consisting of 16 pages and issued by the Edison Storage Battery Car Company, New York. Illustrations show cars in service in various parts of the United States, Central and South America, Mexico and Alaska. A short analysis is included of the relative costs of storage battery and steam operation on the Long Island Railroad and the Edison nickel-iron-alkaline storage battery is described.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis., is distributing a four-page illustrated folder entitled "Miscellaneous Applications of Electrical Heat." The pamphlet is devoted to a description of the standardized unit manufactured by the company. This unit is 2 ft. long, 3/16 in. thick and 1½ in. wide. These units may be used in series or in parallel, according to the voltage of the circuit to which they are connected. They are especially useful in crane and hoist cabs, meter houses, valve houses, and similar locations.

Davis-Bournonville Company, Jersey City, N. J., is distributing a small envelope folder in which is described and illustrated the Davis acetylene flare light. The outfit is a portable outdoor lighting apparatus and weighs about 40 lb., and which produces a powerful white light at low cost.

Electric Service Supplies Company, New York, in its bulletin No. 157, illustrates and describes the "Golden Glow" demountable mirrored unit. These mirrored units are supplies for practically all of the standard 18 in. cases now in general use, and are so constructed as to slide into same without the necessity for fitting or other alterations.

"The Benjamin Reflector," the new house organ of the Benjamin Electric Manufacturing Company of Chicago, made its appearance last month. The new member of the house organ tribe differs considerably from the general appearance of most of the other members of this family. The new publication measures 11 in. by 15 in. and contains eight pages. For the greater part it deals with the personnel of the company and will doubtless be read with interest by all of the employees.

Railway Electrical Engineer

Volume 11 March, 1920 Number 3

WHAT A WELDING OPERATOR MUST KNOW

There are certain fundamental facts which must be kept in the mind by the welding operator. He must apply these facts diligently and conscientiously if he is really desirous of becoming a first-class operator.

Given the best grade of wire obtainable and a good ground connection with the machine set for proper voltage and current, a man of ordinary mechanical ability will in thirty days be able to hold the arc effectively enough to make a weld. If, however, the man then decides he can rest on his laurels and consider from then on that he is an expert welder, it will be most unfortunate for all concerned. Good welding means that the operator must never relax his vigilance. He must apply his principles assiduously—and for the operator who wants to know, the article in this issue on the practical side of electric welding will be of unusual interest.

ELECTRIC TRUCKS TO CUT DOWN HANDLING COSTS

It is easy to arrive at conclusions which are quite erroneous in a superficial consideration of the various problems involved in the handling of materials. A large percentage of the freight carried by the railroads is transported to and from the cars at the teminals by trucks, either horsedrawn or of the motor type. Recently, a writer deplored the apparent discrepancies in the cost of transportation of a certain piece of furniture that had been sent by freight for a distance of several hundred miles. The point of argument was to show that the railroads had carried the shipment many miles at a much lower cost than was made by the truck-driver in transferring the crate from the car to its ultimate destination —a distance of less than a mile. The writer even stated that had the railroads charged at the same rate as the truckman, the cost of railroad transportation would have been nearly two hundred dollars.

The factor which was entirely disregarded was that the major portion of both the railroad company's charge and the truck-driver's charge was for handling the goods and not for the actual transportation. Viewing the matter from this angle puts it in quite a different light. Naturally the railroads handling many different pieces of freight can do it much more economically than the individual who can only handle a limited number in a single day, and whose charges must be based on his own personal capacity. In spite of the economy that arises from handling material in large quantities the cost of moving freight from producer to consumer is actually more than it should be—due principally to the cost of handling. There are indications that this cost of handling will be cut down very appreciably in the future by the greatly extended use of electric trucks and tractors at railroad terminals.

Extension in the use of material handling equipment is one of the urgent necessities in many large freight stations. If the products of industry are to be handled with despatch, a condition unknown to government operation, steps should be taken at once to put into operation just as many electric trucks and tractors as the requirements may dictate. Of course, the increased capacity thus acquired could be had by additional freight sheds and tracks, but even these improvements could not begin to solve the problem in the same way that the electrically operated equipment will do it. Additional freight handling facilities are needed now. New buildings and tracks require time for their construction to say nothing of the high cost of such work. Electric trucks offer an immediate solution of the problem; they will quickly give the desired relief and give it at a cost which is small compared with that of the alternative plan.

PUNISHMENT OR REWARD

There are two means by which most of us are constrained to keep in the straight and narrow path, not only as regards our moral habits, but with our industrial habits as well. One of these means is the fear of punishment if we fail to measure up to the standards set for us; the other is the enticing prospect of reward for work well done. It is quite clear that the first restraining influence is distinctly negative in its suggestion. There is a forbidding atmosphere about it; its strongest appeal is to the lower type of mind. A good example is seen in the man who remains away from his post of duty without cause or reason except to avoid doing the work for which he is paid. He works when he has to—just enough to keep from being discharged, and prides himself on being able to "get away with it."

What a difference there is between such a man and one who is really interested in his work, who each day tries to do his level best. The second man is inspired by the hope of reward, although he may not even recognize it as such. It is not a reward of money, although that, too, will come, but it is the reward of genuine satisfaction that comes from a knowledge of work well performed. To the industrious man the hours of the day seem to fly; to the sluggard each hour seems like eternity.

In the industrial world today these two types of men are traveling side by side. Unfortunately, due to the weaknesses of human nature, bad preaching of incompetent leaders and other depressing conditions, the industrious man is far outnumbered. The hope of the country lies in its ability to reverse the present attitude of its industrial workers. Men must be made to realize that every increase in wages without a corresponding increase in production means simply another boost in prices.

There are many people today who well remember what happened in 1873. It is not a pleasant thing to feel ourselves driven to do our duty by fear of punishment in the form of a panic. Let every man cross-question himself and find out in which of the two classes he belongs. If he finds himself in the wrong crowd let him change his point of view. Let him breathe in some of the atmosphere of industry, banish the dread of punishment and enjoy the full satisfaction of work well done. Then it will be, and only then, that we can face the future with a certain knowledge of a great and lasting prosperity.

WILL YOU DO YOUR PART?

The railroads were returned to their owners on March 1 in an orderly manner and without much fuss. The Esch-Cummins bill, which was finally passed by Congress, appears to be about the best bill that could be agreed upon at this time by Congress and the Administration. It greatly extends the responsibilities and authority of the Interstate Commerce Commission, and on its face would appear to promise a fair return to the stock and security holders if the Commission takes a broad view of the situation and deals with the railroads on a reasonably fair basis.

The railroad corporations have, of course, not yet had an opportunity to take stock of the condition of the roads as they were returned to them. This much is true, however: The facilities and equipment are, generally speaking, not in as good condition as when they were turned over to the government, and the traffic demands today are far greater than they were two years ago. Both wages and material have gone up, and there is a scarcity of both, even at present prices. The morale of most of the organizations has suffered greatly, and the men generally are not giving the same output or effort as they were when they received the much smaller wages prior to government control. This much is to be said, however, about the labor situation: both the managements and the men have been forced to give more or less thought to the labor problem, and there is little question but that on most roads conditions are ripe for bringing about a closer cooperation between the two elements and bridging over the gulf between them that was gradually widening in pre-war days. More than this, both the managements and the men have come to a realization that, after all, the public, or the third party, is just as vitally interested in the proper adjustment of their difficulties as they are themselves. The long suffering and much-abused public has finally awakened and is going to insist upon having service—and service of the right kind.

If good service is not forthcoming, the party which is at fault will have some difficulty in dealing with the public. Unfortunately, some of the managements and some of the employees do not seem to understand this, and have already started to pile up trouble for themselves. The wise railroad manager is going to insist upon giving the very best service and will take pains to explain to the public just why it is not possible to do better. It is necessary, in order to give this improved service, that the capacity of the railroad facilities be greatly increased.

It will be difficult to finance any large physical improvements and in many cases it will be impossible to secure the labor and material necessary to make them even if the money is available. The production of the manufacturing industries is suffering today because the railroads cannot handle all the traffic that is offered to them. There is only one way in which the capacity can be increased to meet the present demands, and that is by so improving the organization and by developing the morale or esprit de corps to such a point that the employees throughout the entire organization will put forth their best efforts. There are too many slackers on the job now and too little attention is being given to cutting out waste and lost motion. This is so apparent that the public itself is easily recognizing it in some cases and will hold it against the roads unless steps are taken to have it promptly corrected.

The employees of the electrical department may be an important factor in helping the situation. The proper upkeep and maintenance of the electrically operated devices and apparatus will not only add to the convenience and comfort of the traveler, but will tend for greater efficiency throughout the operating and maintenance departments. The railway electrical engineer has done a lot of boosting about electrically operated apparatus as a "capacity increaser." Let him do his full share at this time in seeing that the best use is made of this apparatus so that capacity may actually be increased.

NEW BOOKS

Electric Lighting. By Olin Jerome Ferguson, B. S. in E. E., M. E. E., professor of electrical engineering, University of Nebraska; 244 pages. Published by McGraw-Hill Book Company, Inc., 239 West 39th Street, New York.

This is a comprehensive treatise on the subject of electric lighting including much practical information on the various phases of the illuminating art. The opening chapters are devoted to such fundamentals as conductors, wiring, circuits and apparatus. Numerous sketches, tables and charts are included to supplement the text. The history and development of the incandescent lamp is treated at some length, and the arc lamp, Moore tube, and mercury vapor lamp are also touched upon. The science of illumination, the physical laws of light and the relation of both of these to the physiology of the eye are fully considered. The subject of photometry occupies a very appreciable portion of the book. Various types of shades and reflectors are discussed and a lengthy chapter on illumination calculations is included. The application of lighting to residences, stores, factories, auditoriums, schools and streets is treated at length. The book is well illustrated both with diagrams and photographs.

A 100-Car, 5,000-Ton Freight Train; East-Bound at Thelma on the St. Paul.

Steam and Electric Motive Power Compared

From Which It Would Appear that the Steam Locomotive Has About Outlived Its Usefulness

By A. H. Armstrong

RAILWAY AND TRACTION ENGINEERING DEPARTMENT, GENERAL ELECTRIC COMPANY

DURING the year 1920 the people of the United States will pay out for automobiles, not commercial trucks or farm tractors, but pleasure vehicles, a sum of money considerably greater than the estimated requirements of our steam railways for that year. The railways, however, may find it very difficult and perhaps impossible to secure the large sums needed without government aid, notwithstanding the fact that the continued operation and expansion of our roads is of vital necessity to the welfare and prosperity of the country and all its industries. The will of the American public has always been constructive and undoubtedly in due time its voice will be heard and properly interpreted by its representatives in Washington with the resulting enactment of such laws as will permit our railways to again offer an attractive field for the investment of private capital.

The purpose of this paper is not to discuss the politics of the situation nor any necessary increase in freight rates that may be required to make our roads self sustaining, but rather to offer certain suggestions as to the best manner of spending sums that must ultimately be provided for new construction and replacements on the railroads.

During the war period many lessons have been most clearly brought home to us and not the least of these is that there is something inherently wrong with our steam railroads. During the three generations of its development, we have been accustomed to look upon the steam engine as properly belonging to the railway picture with little thought given to its wastefulness and limitations, but around which railway practice of today has gradually crystallized.

During the winter of 1917-18 our railways fell down badly when the need was the greatest in their history. It is true that the cold weather conditions were unprecedented, and the volume of traffic abnormal, but the weaknesses of steam engine haulage were disclosed in a most startling and disastrous manner. Delayed passenger trains in cold weather can be endured by the traveling public in suffering silence or voluble expression, according to temperament, but blocking our tracks with frozen engines and trains, serious reduction of tonnage in cold weather and the prohibitive delay in transportation of freight in times of great stress is quite another thing and plainly indicates the inability of the steam engine to meet overloads and adverse climatic conditions.

In marked contrast to the adjoining steam engine divisions, the 440 miles of electrified section of the Chicago, Milwaukee & St. Paul continued to do business as usual all through that trying winter of 1917-18. The electric locomotives brought both freight and passenger trains over the electrified tracks on schedule time or better; in fact, it was quite customary to make up on the 440-mile electric run fully two hours of the time lost by passenger trains on adjoining steam engine divisions. While the results obtained upon the Chicago, Milwaukee & St. Paul were perhaps more spectacular due to the greater mileage electrifically equipped, other electrified roads contributed similarly attractive records. The reliability and permanency of the comparison between steam and electric locomotive haulage is sufficiently guaranteed therefore by the results of several years' operation, to justify drawing certain conclusions regarding the merits of the two types of motive power. The following analysis of the railway situation is therefore offered for the purpose of exposing the fact that railroading today is in reality steam engine railroading and the general introduction of the electric locomotive will permit fundamental and far-reaching changes being made in the method and cost of hauling freight and passenger trains.

---

*Abstract of an address delivered before the Schenectady section of the American Institute of Electrical Engineers.

The writer is not proposing the immediate electrification of all the railways in the United States, as many roads of lean tonnage would render no adequate return upon the large capital investment required, but offers the following table of total operating statistics simply as a measure of the magnitude of the problem confronting us in the future. In this country it should be noted, however, that we have already installed electric power stations during the past 30 years equal to twice the estimated capacity required for the electrical operation of every mile of track in the country today.

The tonnage passing over the tracks of our railways may be subdivided in a most interesting manner as shown in Table I.

TABLE I

TOTAL TON-MILE MOVEMENT

All Railways in United States Year 1918

		Per cent	Ton miles
1.	Misc. frt. cars and contents	42.3	515,000,000,000
2.	Revenue coal cars and contents	16.23	197,000,000,000
3.	Loco. revenue driver wt. only	10.90	132,300,000.000
4.	Railway cars, all classes	16.13	196,000,000,000
	Total revenue frt. and passenger	85.56	1,040,300,000,000
5.	Railway coal	5.00	60,600,000,000
6.	Tenders, all classes	6.50	78,800,000,000
7.	Locomotive railway coal	.39	4,700,000,000
8.	Locomotive non-driving wt.	2.55	31,000,000,000
	Total non-revenue wt.	14.44	175,100,000,000
	Grand total, all classes	100.00	1,215,400,000,000

The first four items, representing 85.56 per cent of the total ton miles made during the year 1918 may be regarded as fundamentally common to both steam and electric operation. The last four items, however, are seriously affected by introducing the electric locomotive to the extent of completely eliminating items 6 and 7, reducing item 5 by possibly 80 per cent and item 8 by one half. Of the total of 14.64 per cent affected, therefore, it may be assumed for purposes of comparison that approximately 12 per cent or 146,000,000,000 ton miles at present hauled by steam engines over our roads will be totally eliminated with electric locomotive haulage. This ton mileage eliminated is equal to over 20 per cent of items 1 and 2 representing the revenue producing freight traffic on our railways. In other words, if all our railways were completely electrified they could carry one-fifth more revenue producing freight tonnage with no change in present operating expenses or track congestion.

It is evident that the greater part of the tonnage reduction effected by electrification is included in items 5 and 6 representing the railway coal movement in cars and engine tenders. The steam engine tender will, of course, entirely disappear while the railway coal haulage will be largely curtailed by utilization of water as a source of power and the establishment of steam power houses as near the coal mines as an abundant supply of good condensing water and load demand will permit. While water power should be utilized to the fullest economical extent, the greater portion of the railway power must undoubtedly be supplied by coal, due to the unequal geographical distribution of water power available.

Two-Thirds of the Coal Wasted

Even with coal as a source of power, it may not be fully appreciated just how enormous is the saving made by burning fuel in large modern power stations under the most efficient conditions possible, instead of under the boilers of 36,000 engines, which by necessity must be designed and operated for service rather than for fuel economy. During the year 1918 the fuel used by railways is reported as shown in Table II:

TABLE II

Railway Fuel 1918

Total coal production, all grades	678,211,000 tons
Used by steam railways	163,000,000 tons
Percentage of total	24 per cent
Total oil marketed U. S	355,927,000 bbls.
Used by steam railways	45,700,000 bbls.
Percentage of total	5.8 per cent
Coal equivalent of oil at 31½ bbls	13,000,000 tons
Total equivalent railway coal	176,000,000 tons

A quarter of all the coal mined in the United States is consumed on our railways and the following analysis will point out some features of this extreme wastefulness which are inseparable from steam engine operation.

During the year 1910, exhaustive tests were made upon the Rocky Mountain division of the C., M. & St. P. to determine the relation existing between horse power hours work done in moving trains and coal and water consumed on the steam engines in service. The summary, Table III, gives the result of these tests.

TABLE III

C. M. & ST. P.—ROCKY MOUNTAIN DIVISION

Coal and Water Used

	Water per hp.	Water per lb. coal	Coal per hp. hr.
Three Forks-Piedmont	39.6	5.08	7.75
Piedmont-Donald	35.4	4.70	7.54
Deer Lodge-Butte	39.7	4.85	8.31
Butte-Donald	40.4	4.86	8.74
Harlowton-Jenny	38.0	4.09	8.90
Jenny-Summit	44.2	4.65	9.48
Three Forks-Piedmont	41.4	6.51	6.37
Fiedmont-Donald	40.2	5.63	5.78
Average of 8 tests	39.86	5.04	7.86

The above records were obtained during the portion of the runs that the engines were doing useful work in overcoming train and grade resistance, that is, all standby losses were excluded. The through run, however, included such losses in the following magnitude.

Adding stand-by losses to the average of 7.86 lb. per hp. obtained in the preceding eight tests, the total actual coal consumed under the engine boiler in 24 hours divided by the actual work performed by the engine was found to be 10.18 lb. per hp. at the driver rims.

TABLE IV

STANDBY LOSSES

	Coal per hour
Fire banked in roundhouse	150 lb.
Cleaning fires for starting	800 lb.
Coasting down grade	950 lb.
Standing on passing track	500 lb.

As the result of this particular series of tests it was determined that standby losses raised the coal consumed while doing useful work by 30 per cent. It should be appreciated in this connection, moreover, that this value was obtained on through runs with no yard switching service or adverse climatic conditions. It may be concluded therefore that under all conditions of service fully one-third the coal burned on our steam engines today is absolutely wasted in standby losses of the general nature indicated above.

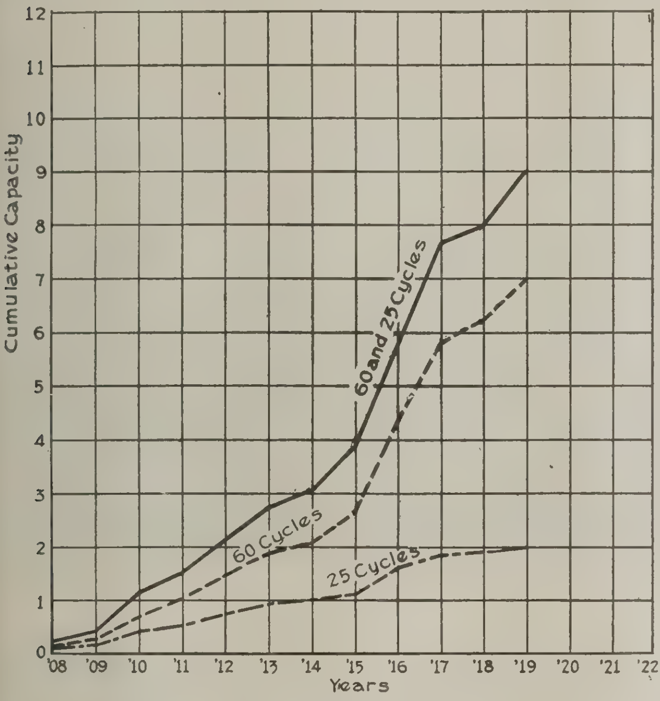
Supplementing these tests, a thirty-day record was kept of all coal used on the entire Rocky Mountain division and the total engine, tender and train movement reduced to horsepower hours, resulting in a value of 10.53 lb. coal consumed per hp. at the driver rims. Both the above values were based upon constants of 6 lb. per ton train resistance at all speeds and seven-tenths lb. per ton per degree of curvature as determined in part by dynamometer car tests and representative of general railway operation. Reducing the average coal values of test runs and 30-day record per hp. hour to electrical constants we arrive at the results shown in Table V.

TABLE V

COAL EQUIVALENT PER KW. HR.—STEAM OPERATION

Coal per hp. hr at driver rims	10.27 lb.
Coal per kw. hr. at driver rims	13.75 lb.
Coal per kw. hr. at power supply on basis 55 per cent efficiency	7.56 lb.

It is this last figure of 7.56 lb. of coal burned on steam engines to get the equivalent tonnage movement of 1 kw. hr. delivered from an electric power station that is of special interest to this discussion. Comparing coal and electrical records on the Butte, Anaconda & Pacific before and after electrification results in arriving at a value of 7.17 lb. of coal previously burned on the steam engines to equal the same service now performed by one kilowatt hour input at the substations, a figure comparing favorably with 7.56 lb. above arrived at by an entirely different method.



Comparative Sales of 60 and 25 Cycle Turbines

Making due allowances for the fact that Roundup coal is somewhat low in heat units, it is nevertheless within the limits of reasonable accuracy to assume that the steam engines operating over all our railways are consuming coal at a rate closely approximating 12.75 lb. of coal per kilowatt hour of useful work done, as measured at the driver rims or 7 lb. per kilowatt hour as measured at a power station and including for convenience of comparison the transmission and conversion losses inherent to electrical operation.

ANALYSIS OF ROUNDUP COAL USED

Fixed carbon	49.26 per cent
Volatile carbon	38.12 per cent
Ash	7.74 per cent
Moisture	4.88 per cent
B. t. u.'s	11,899

An electric kilowatt can be produced for so much less coal expenditure than 7 lb. that we are now in a position finally to forecast the approximate extent of the coal economy that would result from electrification.

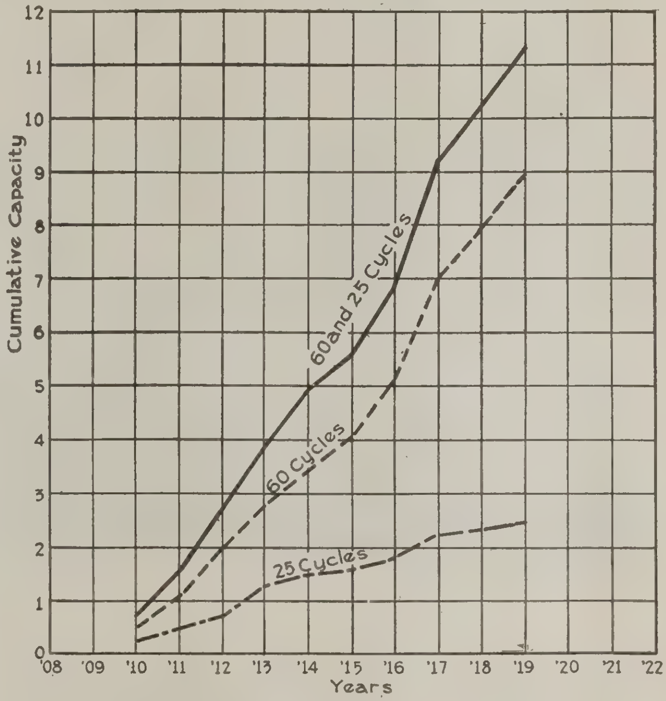
TABLE VI

RELATION BETWEEN KW. HR. AND TON MILES

C. M. & St. P. Avery-Harlowton, Year 1918

	Passenger Tons	Freight. Tons.
Average weight locomotive	300	284
Locomotive miles 1918	651,000	1,431,500
Loco. ton miles	195,000,000	407,000,000
Trailing ton miles	434,406,000	2,903,099,000
Total ton miles	629,406,000	3,310,049,000
Kilowatt hours	24,890,000	105,287,000
Watt hrs. per ton mile	39.6	31.9
Ratio loco. to total	31%	12.3%
Watt hrs. per ton mile combined movement		33.2
Ratio loco. to total combined movement		15.25%

All power values (Table VI) are given at the point of supply from the Montana Power Company at 100,000 volts, and include deductions made for the return of power due to regenerative braking of the electric locomotives on down grades and amounting to approximately 14 per cent of the total. Owing to the excessive rise and fall of the profile of the electrified zone of the C., M. & St. P., its operation is materially benefited by regenerative electric braking and the value of 33.2 watt hours per ton mile for combined and passenger movement ment should possibly be raised to the round figure of 40 to make it apply more nearly to conditions universally obtaining on more regular profiles.



Comparative Sales of 60 and 25 Cycle Transformers

Hence referring again to the ton mile values of Table I:

Total ton miles 1918	1,215,400,000,000
Watt hrs. ton mile	40
Kw. hrs. total movement	48,007,000,000
Coal required at 7 lb. per kw. hr	170,000,000 tons

The actual equivalent coal consumed on our steam railways for the year 1918 is given as 176,000,000 tons, closely approximating the figure of 170,000,000 tons estimated above from the operating results obtained on the C., M. & St. P. electrified zone. These several values check so closely as to justify the completion of the fuel analysis of the railways, Table VII.

TABLE VII

COAL SAVING BY ELECTRIFICATION

Total ton miles steam	1,215,400,000,000
Reduction by electrification	146,000 000,000
Total ton miles electric	1,069,400,000.000
Kw. hrs. electric at 40 watts	42,776,000,000
	Tons
Coal on basis 2½ lb. per kw. hr	53,500,000
Equivalent railway coal 1918	176,000,000
Saving by electrification	122,500,000

The startling conclusion arrived at is that approximately 122,500,000 tons of coal or more than two-thirds the coal now burned on our 63,000 steam engines would have been saved during the year 1918, had the railways of the United States been completely electrified along lines fully tried out and proved successful today. This vast amount of coal is 50 per cent greater than the pre-war exports of England, and twice the total amount consumed in France for all its railways and industries. Moreover, the estimate is probably too conservative, as no allowance has been made for the extensive utilization of water power which can be developed to produce power more cheaply than by coal in many favored localities.

The Grand Central Terminal, New York, as It Appeared in 1906

From figures given, the following conclusion is arrived at in the matter of power station capacity required for complete electrification of the railways in the United States.

RAILWAY POWER REQUIRED

Kw. hr. electric operation 1918	42,776,000,000 kw. hr.
Average load 100 per cent load factor	4,875,000 kw.
Power station capacity at 50 per cent load factor	9,750,000 kw.

It appears therefore that approximately 10,000,000 kw. power station capacity would have been sufficient to run all the railroads for the year 1918, or one-half the station capacity which has been constructed during the past thirty years.

In order of magnitude, therefore, it is not such a formidable problem to consider the matter of power supply for our electrified railways, and it becomes evident also that the railway power demand will be secondary to industrial and miscellaneous requirements.

TABLE VIII

ESTIMATED POWER STATION CAPACITY UNITED STATES YEAR 1918

	Kw.
Central stations	9,000,000
Electric railways	3,000,000
Isolated plants	8,000,000
Total	20,000,000

Such being the case, the question of frequency of electric power supply becomes of great importance, if full benefit is to be obtained from extensive interconnected generating and transmission systems, covering the entire country. Indeed, with full development of interconnected power systems supplying both railway and industrial load from the same transmission wires, the above assumption of 50 per cent load factor for the railway load can be materially bettered.

TABLE IX

LOAD FACTOR RECORDS, C. M. & ST. P., 1919

	Duration of peak, per cent	Load factor, per cent
April	6.4	59.3
May	4.6	56.1
June	1.6	56.5
July	0.7	55.6
August	4.1	54.7
September	9.5	58.8

In this connection a method of limiting the troublesome peak load hitherto considered inherent to railway power supply has been in successful operation on the electrified C., M. & St. P. zone for the past year. With unrestrained peaks, the load factor was approximately 40 per cent, but this low value has been raised to nearly 60 per cent by the installation of this inexpensive and most satisfactory device, known as the power limiting and indicating apparatus.

The above readings cover the performance on the 220 miles of the Rocky Mountain division supplied by seven substations controlled as a unit. A load factor of nearly 60 per cent brings the electric railway within the list of desirable customers and makes it possible for power companies to quote attractively low rates for power.

Returning again to the question of power supply, it is instructive to note the general trend toward a higher frequency as evidenced by the turbine and transformer sales of the General Electric Company during the past decade.

It is quite evident that 60 cycles is rapidly becoming the standard frequency in America and many instances are of record where it has replaced lower frequencies, principally 25 cycles. This fact in no manner handicaps the future development of electric railways, as entirely satisfactory power can be obtained from 60 cycle transmission lines through rotary converters or synchronous motor generator sets, depending upon the direct current trolley voltage desired. Indeed, a growing appreciation of the declining importance of 25 cycle power generation in this country contributed largely to the demise of the single phase system as its chief claim for recognition is wiped out with the introduction of the motor generator substations required with 60-cycle supply.

From the power station standpoint, the electrification of our railroads admits but one conclusion. We have some 63,000 engines now in operation and their average combined load amounts to approximately four million horsepower at the driver rims, or only an insignificant total of 65 hp. for each engine owned. It is true that owing to shopping and for one cause or another a large proportion of these engines are not in active service at all times, still the average 24-hour output of each engine is less than 10 per cent of its rating. In the case of the C., M. & S. P. electrification, the average load of each individual electric locomotive is only 15 per cent of its continuous rating, but by supplying power to 45 electric locomotives from one transmission system, the average combined load factor is raised to nearly 60 per cent, a figure which could even be surpassed on roads of more regular profile. Furthermore, when the railway load is merged with the lighting and industrial power of the district and the whole diversified load supplied from the same 60 cycle transmission and generating system, it is quite evident that all the conditions are most favorable for the efficient production of power. In this country such an achievement will probably be governed by the laws of economic return upon the capital required, because our vast natural fuel resources are popularly regarded as inexhaustible, but in Europe there is the compelling spur of stern necessity behind the movement to economically utilize the water powers they possess in place of the coal they cannot get.

While the much discussed subject of power generation and transmission is a very vital part of the railway electrification project, chief interest centers in the electric locomotives itself. Few realize what a truly wonderful development has taken place in this connection in a comparatively few years and how peculiarly fitted this type of motive power is to meet the requirements of rail transportation. Free from the limitations of the steam boiler and possessing in the electric motor, the most efficient and flexible known means of transmitting power to the driving axles, the electric locomotive gives promise of revolutionizing present steam railway practice when its capabilities become fully recognized. The only limits placed upon the speed and hauling capacity of a single locomotive are those imposed by track alinement and standard draft rigging. Only questions of cost and expediency control the size of the locomotive that can be built and operated by one man, as there are no mechanical or electrical limitations that have not been brushed aside by careful development. Just what this means in advancing the art of railroading is as yet but faintly grasped any more than the boldest prophet of 20 years ago could have fully pictured the change that has taken place at the Grand Central terminal, as the result of replacing steam by electricity.

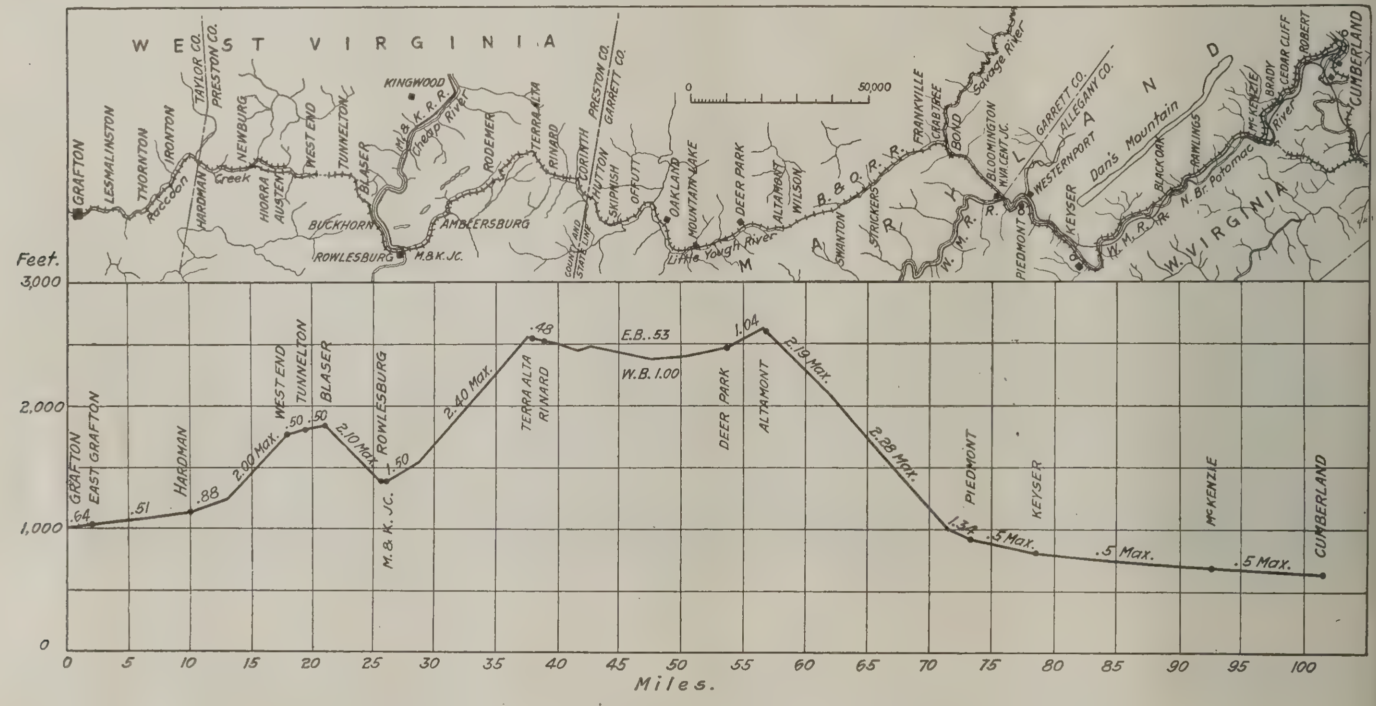
Progress in utilizing the capabilities of the electric locomotive has been slow. It is hard to break away from life-long railway traditions established by costly experience in many cases. In consequence, the electric locomotive has thus far simply replaced the steam engine in nearly similar operation. Even under such conditions of only partial fulfillment of its possibilities, the electric locomotive has scored such a signal operating success as to justify giving it the fullest consideration in future railway improvement plans.

The Grand Central Terminal, New York, as It Appears Since It Was Electrified

On the C., M. & St. P., 42 locomotives have replaced 112 steam engines and are hauling a greater tonnage with reserve capacity for still more. On this and other roads, it has set a new standard for reliability and low cost of operation. In fact, although no official figures have yet been published, it is an open secret that the reduction in previous steam operating expenses on the C., M. & St. P. are sufficient to show an attractive return upon the twelve and a half millions expended for the 440 miles of electrification, without deducting the value of the 112 steam engines released for service elsewhere. As the electric locomotive is destined to leave its deep impression upon the development history of our railways, it is fitting that the remainder of this address should be devoted to its consideration.

Our steam engine construction is unsymmetrical in wheel arrangement, and further handicapped with the addition of a tender to haul its fuel and water supply, must run single ended. The result has been much congestion at terminals and the necessary roundhouses, always with the inevitable turntable, ash pits and coal and water facilities, have occupied much valuable land, and in addition steam operation has greatly depreciated the value of neighboring real estate. The contrast offered by the two large electric terminals in New York City is too apparent to need more than passing comment and similar results may be expected on the fulfillment of plans for electrifying the Chicago terminals.

While it has been a simple matter to design electric locomotives to run double ended at the moderate speeds required in freight service, the problem of higher speed attainment exceeding 60 miles per hour, has presented greater difficulties. The electric motor is, however, so adaptable to the needs of running gear design that electric locomotives are now in operation which can meet all the requirements of high speed passenger train running. These results also are obtained with less than 40,000 lb. total weight and 9,500 lb. non-spring borne or "dead" weight on each driving axle, and finally, but not least, with both front and rear trucks riding equally well, a success never before achieved in locomotives of such large capacity.



Map and Profile of the Cumberland Division of the Baltimore & Ohio

There is as yet no general acceptance of a standard design of electric locomotive. Geared side rod construction for heavy freight service and twin motors geared to a quill for passenger locomotives appear to find favor with the Westinghouse-Baldwin engineers, while the General Electric Company goes in for the simple arrangement of geared axle motors for freight and gearless motors for passenger locomotives. In both Switzerland and Italy the side rod locomotive enjoys an almost exclusive field. How much of this preference for side rod construction is due to the restrictions imposed by the use of alternating current motors is hard to determine, but the facts available indicate the uniformly higher cost of repairs of this more complicated form of mechanical drive both in this country and abroad.

The electric railway situation in Italy is further complicated by the employment of three phase induction motors with all the attendant handicaps of double overhead trolleys, low power factor, constant speeds and overheating of motors resulting from operation on ruling gradients with motors in cascade connection. In many respects the non-flexible three-phase induction motor is poorly adapted to meet the varied requirements of universal electrification, and in consequence Italian engineers are still struggling with the vexing question of system which may, however, be in a fair way of settlement through the adoption of a standard of 50 cycles as the frequency of a nation wide interconnected power supply, thus throwing the preponderance of advantages to high voltage direct current.

Low Cost of Maintenance

The extreme simplicity of the gearless motor locomotive appeals to many as does its enviable record of low maintenance cost, reliability and high operating efficiency, as exemplified by its unvarying performance in the electrified zone of the New York Central for the past twelve years.

TABLE X

MAINTENANCE COSTS, NEW YORK CENTRAL

	1913	1914	1915	1916	1917	1918
Number locomotives owned...........	48	62	63	63	73	73
Average weight, tons................	118	118	118	118	118	118
Cost repairs per locomotive mile (cents)	4.32	4.03	4.45	3.78	4.01	6.26

The high cost of living did not appear to have reached this favored locomotive until the year 1918.

The records on the C., M. & St. P. locomotive are equally remarkable when considering their greater weight and more severe character of the service.

TABLE XI

LOCOMOTIVE MAINTENANCE COSTS, C. M. & ST. P.

	1916	1917	1918
Number locomotives owned.....................	20	44	45
Average weight, tons	290	290	290
Cost repairs per locomotive mile (cents)..........	8.21	9.62	10.87

In both these instances the cost of repairs approaches closely to 3 cents per 100 tons of locomotive weight.

Giving due credit to the excellent repair shop service rendered in each case, it is instructive to note that 3 cents per 100 tons maintenance costs of these direct current locomotives is less than half the figures given for any of the alternating current locomotives operating in the United States or in Europe.

Compared with the cost of repairs of equivalent steam engines, the above figures for electric locomotives are so very favorable as to justify the general statement that electric motive power can be maintained for approximately one-third the cost of steam engines for the same train tonnage handled. As locomotive maintenance is a measure of reliability in service and in a way expresses the number of engine failures, it is quite in keeping with the records available to state also that the electric locomotive has introduced a new standard of reliability that effects material savings in engine and train crew expense as well.

Electrification and Operating Costs

While the first cost of electrification is admittedly high, it may in certain instances be the cheapest way to increase the tonnage carrying capacity of a single track, especially in mountain district where construction is most expensive and steam engine operation most severely handicapped. In this connection a comparison of steam and electric operation on the C., M. & St. P. may be summarized as follows:

For the same freight tonnage handled over the Rocky Mountain division, electric operation has effected a reduction of 22½ per cent in the number of trains, 24.5 per cent in the average time per train and has improved the operating conditions so that nearly 30 per cent more tonnage can be handled by electric operation in about 80 per cent of the time it formerly took to handle the lesser tonnage by steam engines. This means a material increase in capacity of this single track line, which may be conservatively estimated in the order of at least 50 per cent and probably more. In other words, on this particular road, electrification has effected economies which sufficiently justify the capital expenditure incurred and furthermore has postponed for an indefinite period any necessity for constructing a second track through this difficult mountainous country.

A careful study of the seriously congested tracks of the Baltimore & Ohio, between Grafton and Cumberland, disclosed vitally interesting facts. Company coal movement in coal cars and engine tenders constituted over 11 per cent of the total ton miles passing over the tracks. In other words, due to the very broken profile of this division, the equivalent of one train in every nine is required to haul the coal burned on the engines. Taking advantage of this fact and the higher speed and hauling capacity of the electric locomotive and its freedom from delays due to taking on water and fuel, it is estimated that the three tracks now badly congested with present steam engine tonnage, could carry 80 per cent more freight with electric locomotive operation. The coal output of the Fairmont district is largely restricted by the congestion of this division and it is probable that equal relief with continued steam engine operation could not be secured without the expenditure of a much larger sum for additional track facilities than would be needed to put electric locomotives upon the present tracks.

Further instances could be cited where the benefits of electrification are badly needed and many of these are coal carrying roads, among which the Virginian Railway stands out conspicuously as a good opportunity to make both a necessary economic improvement and a sound financial investment.

Reviewing the progress made in a short twenty years, we have seen the steam turbine and electric generator drive the reciprocating engine from the stationary power field. The same replacement is now taking place on our ships, big and small, notwithstanding the fact that the marine reciprocating engine is a very good engine, indeed, and operates under the ideal conditions of a steady load and constant speed. And now the steam locomotive must in turn give way to the electric motor for the same good reasons that the reciprocating steam locomotive has become obsolete and fails to respond to our advancing needs. Electrification affords a cheaper and better means of securing increased track capacity and improved service than by laying more rails and continuing the operation of still more steam engines in the same old wasteful way.

To conclude the startling picture of our present railway inefficiency, we are today wasting enough fuel on our steam engines to pay interest charges on the cost of completely electrifying all the railways in the United States, fuel that Europe stands in sad need of and which England and Germany, the pre-war coal exporting countries, cannot now supply. With operating expenses mounting to 82 per cent of revenue, in addition to constructive legislation and real co-operation on the part of the governemnt in the matter of rates and safe guarding invested capital, is wise direction in the expenditure of the large sums that must speedily be found and used to bring our railways abreast of the times. Accord full honor to the reciprocating steam engine for the great part it has played in the development of our railways and industries, but complete the work by replacing it with the electric motor and enter upon a new era of real railroading.

* * * *

Photo Copyright by Underwood & Underwood, N. Y.

In the Andes on the Peruvian Central

The Practical Side of Electric Welding

By John C. Weis

From recent personal investigations of failures of flue welds, I find that about 95 per cent of them occur where the weld is started. This is caused by the operator drawing his arc at the bottom of the flue too close to the bead. When the arc is first started the metal all around is cold and the first bit of metal which is applied does not weld but simply adheres to the flue sheet; the first one-eighth or one-fourth inch of metal placed is simply stuck to the flue sheet. This any one can prove for his own satisfaction by knocking off the first metal applied with a hammer and cold chilsel. Because of this there is frequently a weak spot in the weld when the operator follows the practice of starting from the bottom of the head, working up the right side as far as the metal at the electrode permits and up the left side from the starting point. This method of welding is shown in the left hand figure of the illustration.

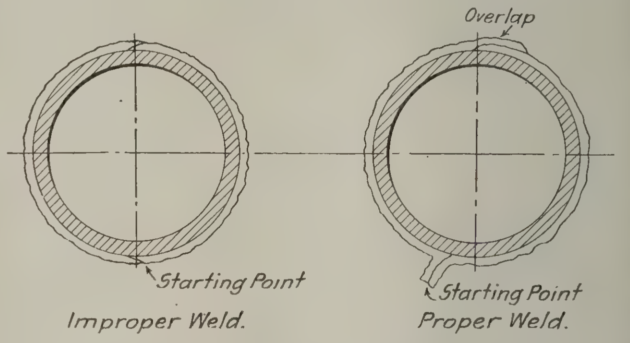
This condition can be entirely eliminated by simply starting the arc at a point from one-fourth inch to one-half inch below the bead of the flue and working up to and around the bead in the manner shown in the right hand picture. This method of procedure will keep the questionable part of the weld away from the flue itself.

For welding two-inch flues, the best results can be obtained with one-eighth inch welding wire, using a current of about 140 amperes and a voltage of about 34 volts across the arc. Care must be exercised in regard to having the boiler filled with water in order to allow for expansion of the sheet, rolling of flues, etc. The following of these few simple rules should be strictly enforced. Many experienced welders will scoff at this statement and will say, "Such caution is absolutely unnecessary, I simply use the arc where it is needed. To them I desire to say that the prospects their becoming real and successful welders are nil. It is a common fault of welders with little experience to boast of their proficiency. My own experience with some of these boasters is that they have missed their calling; they would have made better teamsters.

Too much emphasis cannot be laid upon the fact that it is essential to weld with a short arc. A short arc means that the metal is fusing properly and not sticking loosely upon the surface to be welded. Particularly where a high voltage is used the good operator will "crowd" his arc and disregard the alleged advantage of using a long arc. Each and every operator should first get control of his metal, welding with the point and not the side of the electrode and placing the metal where it is needed, maintaining at the same time an arc one-eighth inch long regardless of what voltage or current the machine is set for. It is not easy to do this and success is obtained only by persistent and diligent effort.

Another very important feature that must not be overlooked is that the part or parts to be welded must first be cleaned. They must be cleaned and kept clean during the process of welding or the quality of the weld will be poor. The operator's kit should include a good stiff wire brush, which should be used and not carried around as an ornament. Many welders seem to think the brushes to be ornaments judging from the conditions of the brushes rationed to them when they are returned for new ones. The brushes cannot be used too much to keep dirt and slag from being included in the weld.

The ground wire is an often overlooked source of trouble. Many times I have had good welders under my supervision come to me with that time worn complaint, "this machine is no good," and upon examination find that a ground connection has been made by leaning a small piece of flue or the first piece of iron at hand against the frame of the locomotive or part to be welded. The imperfect and carelessly made ground usually means a considerable loss of time both for the welder and the superintendent. I should also like to suggest that the welder should bear in mind that he is not lowering himself or the dignity of his position by cleaning small parts not properly put in condition even though the cleaning should have been done by someone else. The operator can usually clean these parts in five or ten minutes and thus save the better part of an hour which is usually expended in finding the foreman, making complaints, etc.



Improper and Proper Methods of Welding Boiler Flues to Flue Sheet

A spirit of co-operation is most desirable. The foreman's loss is the welder's loss and it is important that they work in harmony. A spirit of pride is most essential to the good welder. Never perform a sloppy piece of work with the remark "that is good enough," but let your slogan be "the best is not good enough," and strive to this end always. When assigned to perform an operation that is not properly beveled, do not proceed to weld it. If your experience tells you it cannot be done properly, have it chipped out before you begin your weld. If, however, you are assigned to an operation in which the bevel on one side is difficult to reach due to some obstruction such as a waist sheet, it may not be necessary to demand further preparation of the weld, as the work can often be done properly by bending the metal electrode into such a shape that the point of the electrode will reach the part to be welded.

Plans have been prepared for the construction of an inclined electric railway at Montreal, Canada, to carry passengers from the city to the top of Mount Royal. It is proposed that the rails be laid on a solid concrete roadbed. Two alternate plans are mentioned, one for single track and one for double, and it is stated that the journey up the mountain would be accomplished in a little more than one minute, the distance being only 350 feet. The cars proposed will have a seating capacity of 80 passengers.

The Control of Alternating Current Motors

Operating Conditions of Motors are Given Consideration in the Design of Control Apparatus

By Gordon Fox

MOST alternating current motors, like those for direct current, are designed primarily with a view to running conditions. During the starting period a controller must function to modify conditions as required. The controller requirements depend upon the motor type. The following motor types will be considered:

- Single phase motors
- Multiphase motors
  1. Squirrel cage motors.
  2. Wound rotor motors.
  3. Synchronous motors.

Small single phase motors are of several types, series motors and induction motors being the more common. It is desirable for the sake of simplicity, that motors of these small sizes be started by merely connecting them to the service lines. Series motors are well suited to this purpose. Induction motors are adopted to this method of starting by means of split phase windings, self contained. Motors up to ½ h.p. rating, designed in this manner, may be thrown directly upon the power lines with no ill effect. Induction motors of larger size are commonly equipped with a split phase starter; these motors have multiphase primary windings. The split phase starter serves to supply "out of phase" current to the different phase winding of the motor creating a revolving field about the stator similar to that produced in a multiphase motor. A diagram of a split phase starter is shown in Fig. 1. These motors develop only moderate starting torque and require rather heavy starting current. Repulsion motors in combination designs are built capable of connection directly across the power lines in sizes up to about 10 hp. Rheostatic starters are supplied with some of the larger motors, to reduce starting currents.

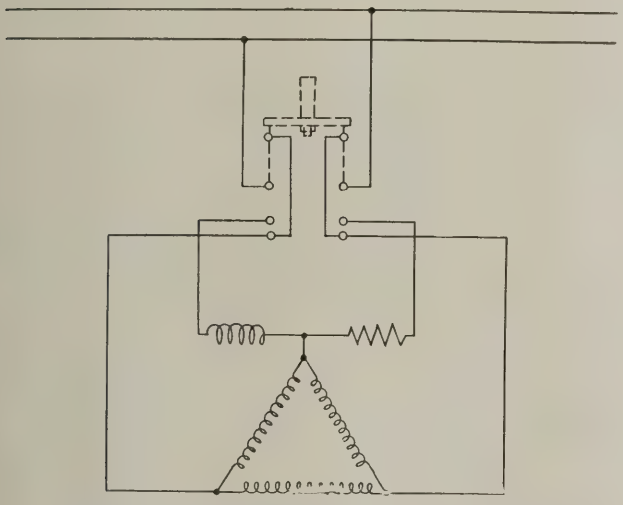


Fig. 1. Diagram of Split Phase Starting Device for Single Phase Induction Motor

Specialized types of repulsion-induction motors are designed for reversing or varying speed services. Some of these motors depend upon brush shifting for their control, a shifting level being mechanically connected to the brush yoke of the motor. Other types require drum controllers, which reverse portions of the stator winding to reverse the rotation and insert resistance in the stator and rotor circuits to increase and decrease the motor speed.

It is obvious that any motor which may be started by closure of a simple switch may also be started by automatic circuit closing devices such as contactors, relays, pressure or vacuum switches, thermostats and the like. Many single phase motors are so controlled.

Multiphase Motors—Squirrel Cage

When voltage is applied to the primary windings of a multiphase induction motor, the revolving field, traveling at synchronous speed, is set up instantly around the stator bore. As the rotor is at stand still the "slip" is a maximum. The entire revolving flux cuts the rotor conductors and sets up in them a comparatively large voltage. This voltage tends to send a heavy current through the rotor which, by transformer action, tends to draw a heavy current in the primary winding.

A standard squirrel cage induction motor, connected directly across full voltage will draw from 500 to 700 per cent rated full load primary current and will develop 125 to 175 per cent full load torque. This inrush of current is only momentary, falling rapidly as the motor attains speed. The magnitude of the first rush of starting current depends upon electrical factors only and is independent of the mechanical motor load. The duration of the starting peak, however, depends upon the time required for acceleration, which in turn depends upon the mechanical load.

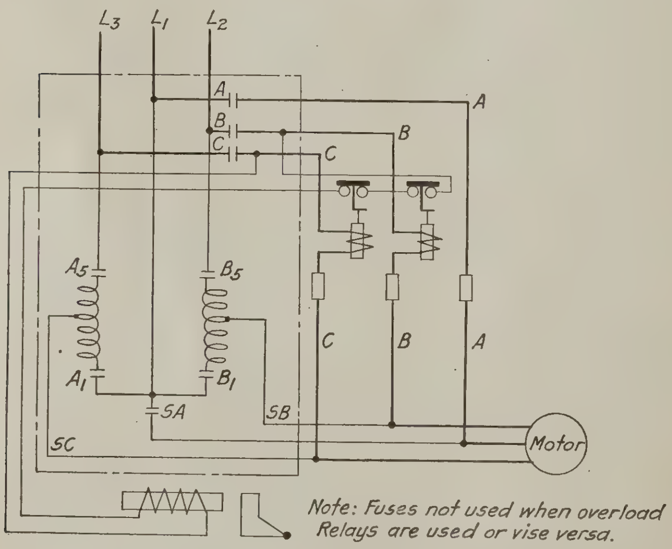
As a current 5 to 7 times normal is too severe upon the motor lines and the resulting starting impulse too sudden, it is necessary to reduce this effect. This can be done, in the case of the squirrel cage motor, only by reducing the impressed primary voltage. The exact values of starting currents and torques produced with different impressed voltages depend upon the

Impressed voltage per cent rated volts	Starting current per cent F. L. current	Starting torque per cent F. L. torque
100	600	175
90	550	150
80	480	110
70	420	80
60	360	60
50	300	40

motor characteristics. Typical values are given in the table.

Reduced voltage for use in starting squirrel cage motors may be provided in several ways. Where transformers are used for the power supply of one or more motors it is possible to take off reduced potential from taps in the secondary winding. Additional leads are run from these taps. The controller merely provides for switching, first to the low voltage taps then to full voltage lines. If standard transformers are used a starting voltage of 50 per cent full voltage may be readily provided. At this voltage the motors will provide about 40 per cent full load torque at starting. This is insufficient in many instances but is satisfactory in some. By means of special taps in the transformers a higher starting potential may be provided and better torques obtained from the motors. This method of securing starting potentials is not extensively employed but it offers possibilities of considerable saving in cost of controllers where conditions are favorable. It is quite commonly employed where transformers are provided to supply single units as in the case of synchronous motors or converters started by induction motor action from the alternating current side.

A reduced potential for starting squirrel cage induction motors may be obtained by providing small transformers for each motor together with means for connecting the motor first to a reduced potential taken from the transformers and then to the lines. These transformers commonly take the form of auto-transformers, to reduce their cost. Manual starters, operating on this principle are called auto-starters or starting compensators. It is customary to provide the auto-transformers with several taps so that various starting voltages may be secured. The transformers may have either two or three coils. For two phase motors only two coils are necessary. For three phase motors two coils may be employed, connected open delta or three coils may be used, being connected in star. Figs. 2 and 3 show the main connections for three phase compensators connected according to these two schemes.



Note: Fuses not used when overload Relays are used or vise versa.

Fig. 2. Diagram of Connections for Auto-Starter

It is to be noted that, when auto-transformers are used, the line current is less than the motor primary current in a degree pending upon the ratio of transformation. This condition will be readily seen by inspection of Fig. 4.

Reduction of impressed voltage may be secured by insertion of resistance in series with the primary windings of the motor. The amount of resistance may be adjusted to secure the desired starting voltage and torque. As the motor attains speed the resistance may be cut out by short circuiting in one or more steps. The primary resistance starter has the advantage of simplicity. It has the disadvantage of lower efficiency and larger current intake from the lines since motor current and line current are the same with this type of starter.

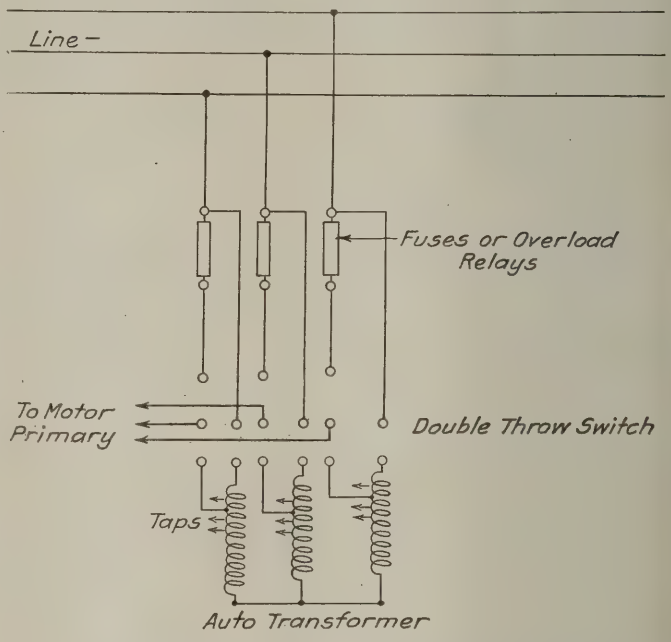


Fig. 3. Diagram for 3-Coil, 3-Phase Starting Compensator for Squirrel Cage Induction Motor

It is possible to utilize a double connection of the motor primary windings to provide reduced starting potential. The primary winding of a three phase motor may be brought out with both ends of each phase ending in a terminal at the motor. The six resulting terminals are connected to a double throw switch, usually of a modified drum type. The connections of this switch are such that, for the starting position, the line voltage is impressed upon the motor coils connected in wye, while, for the running position, the motor windings are connected in delta across the line. The voltage impressed upon each phase winding, wye connected at starting, is thus 58 per cent of the voltage impressed upon the windings delta connected for the running position. The starting current is proportionately reduced. This method is illustrated in Fig. 5 showing connections and voltage relations.

A disadvantage incident to this so called wye-delta starting method lies in the fact that the starting voltage can have but one value, namely 58 percent of line voltage. Where the torque required for starting is at all heavy, this low voltage may prove insufficient. Another disadvantage lies in the necessity of winding the motors for delta connection for line voltage. There are some advantages for the wye connection which cannot be realized if this starting method be used. The advantage of the method lies in the simplicity and cheapness of the starting device.

The characteristics of an induction motor are so affected by its secondary resistance that excellent starting performance may be secured from motors so constructed that their secondary resistance may be varied during the starting period. The wound rotor induction motor has its rotor windings brought out to slip rings. External resistance of any desired value may be connected between these rings. The external resistance may be varied at will. By this means it is possible to limit both starting current and torque to desired values. After the motor has started the resistance may be adjusted to secure the desired running conditions.

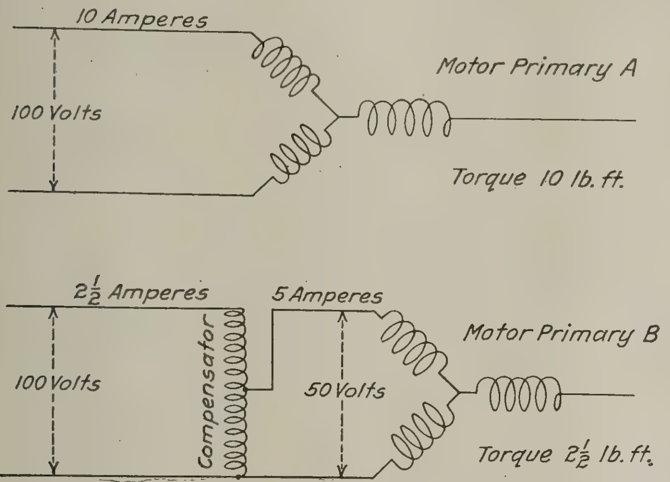


Fig. 4. Induction Motor Starting Current With and Without Starting Transformers

The conditions which govern the starting performance of a wound rotor type of induction motor may be most readily observed by inspection of the characteristic curves of a motor of this type. Figure 6 gives a typical set of curves showing the relations between torque, speed and primary current with various values of secondary resistance.

In starting a motor we deal first with the conditions at zero speed. It will be noted that curve *A*, showing a condition of low secondary resistance, indicates a standstill torque about equal to full load motor torque and a corresponding primary current (with full primary voltage) of about six times full load value. As soon as some speed is attained the torque increases and the current rapidly decreases. This condition is comparable to the starting condition for the squirrel cage type of motor. Curve *B* shows that an increase in secondary resistance produces greater torque at standstill with lesser primary current. Curves *C* and *D* show further improvement until, with resistance as of curve *D*, we secure maximum or pull out torque of the motor with a current about four times full load value. If we increase the secondary resistance still further as shown by curve *E* the torque at standstill decreases the maximum torque now occurring at negative speed corresponding to a "plugging" condition. The primary current at standstill has also decreased. Curve *F* shows that, by insertion of sufficient secondary resistance it is possible to secure full load torque at standstill with approximately full load primary current input.

The above curves all show conditions existing with full voltage impressed upon the primary winding of the motor but with the secondary resistance varied. Since it is possible to control the starting performance of motors of this type so excellently by adjustment of the secondary resistance there is no need for reduction of the impressed primary voltage during the starting period. The primary winding is therefore connected directly across the line . The control for a wound rotor type of induction motor must care for primary and secondary circuits. It must provide a means for connecting and disconnecting the primary winding from the source of power and it must provide a means for varying the secondary resistance.

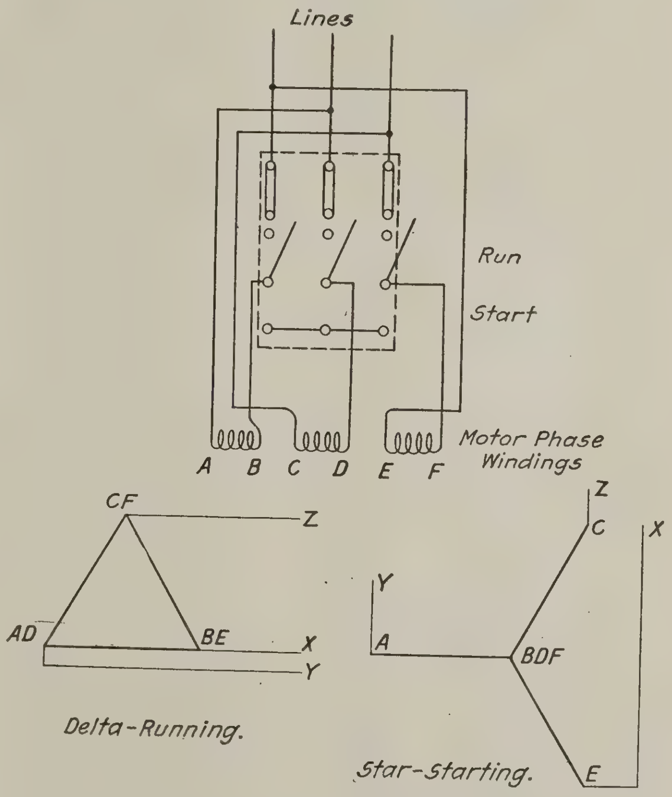


Fig. 5. Star-Delta Starting of Three-Phase Induction Motor—Diagram and Voltage Relations

The synchronous motor, as its name implies, is operative only at synchronous speed. At standstill it has no torque produced by synchronous motor action. It is necessary to accelerate motors of this type to approximately synchronous speed before they become operative as synchronous motors. If this is done by means of an auxiliary motor of another unit the control for the synchronous motor becomes merely a means for switching the synchronous motor onto its system when the condition of synchronism is reached, together with means to indicate this synchronous condition and means to control the direct current for the fields.

The so called "self starting" synchronous motor secures its starting effort entirely by induction motor action. The majority of self starting synchronous motors are provided with a squirrel cage winding on the rotor. This winding is employed to transform the motor, during the starting period, into a modified squirrel cage induction motor. To start a motor of this type it is necessary to connect its primary or stator winding across a reduced potential just as is done in the case of the squirrel cage induction motor. This reduced voltage may be secured by any of the methods employed in providing reduced starting voltages for induction motors. The control for a synchronous motor of the "self starting" type must comprise; a means for connecting the primary first across a reduced voltage and then across full voltage: a means for connecting the fields across a resistance during the starting period and to their direct current source after the motor has accelerated; a means for adjusting the motor field strength; instruments and protective features as required.

Some self starting synchronous motors carry a winding in the rotor element which may be employed as an induction motor secondary winding during the starting period and as a field winding during synchronous running period. In starting, the primary winding is switched across the full alternating voltage, a resistance being connected across the slip rings at which the rotor windings terminate. As the motor accelerates this secondary resistance is reduced so that the motor may be brought to nearly synchronous speed by induction motor action. At this point direct current is introduced into the rotor circuit and the resistance is discounted. The control must include the necessary devices to perform these switching operations.

To Control Direction of Rotation

The direction of rotation of a multiphase induction motor, of either squirrel cage or wound rotor type, and that of a synchronous motor, as well, is governed by the direction of rotation of the revolving field about the stator bore. This revolving field is set up by currents, out of phase with each other, passing through coils so located that the flux travels around the stator as the coils are successively energized. It is evident that a certain sequence of currents passing through a given sequence of coils, will cause the flux to travel in one manner. A different sequence of currents, passing through the same sequence of coils, will cause the flux to travel in a different manner. Interchange of two primary leads in a three phase motor causes the currents in the coils of these two phases to reach their crest values at interchanged periods with reference to the crest current in the third phase. This reverses the direction of travel of the flux from coil to coil, reversing the direction of the revolving field. Reversing the revolving field causes the rotor to follow behind the revolving field in the reverse direction. To reverse the rotation of a three phase motor it is only necessary to interchange any two of the three primary leads. To reverse a two phase motor the two primary leads of either phase must be interchanged.

The great majority of induction motors and all synchronous motors are operated in a single direction determined at the time of installation. Direction of rotation is then merely a matter of connections. Some induction motors are called upon to run in reverse direction only occasionally, as for a backing off operation. In such cases some type of throw over switch is commonly installed to reverse the primary leads while the motor is at rest. It is then started in the reverse direction in a normal manner. Actual "reversing duty" is required of but a small minority of induction motors. Ordinary squirrel cage motors are not adapted to this service. Reversing duty is more commonly handled by the use of wound rotor motors, the control including switching equipment for reversing the primary leads and means for controlling the secondary resistance, and two functions being so interlocked that full secondary resistance must be in circuit when the primary is reversed.

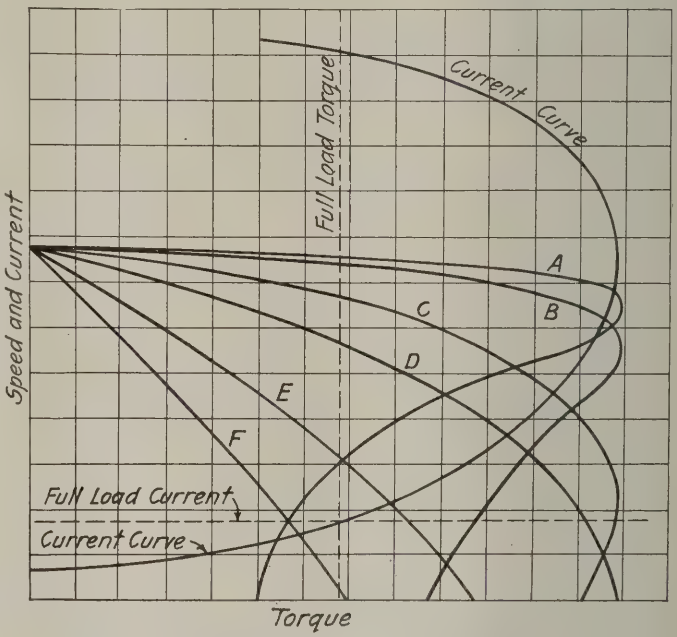


Fig. 6. Characteristics of Wound Rotor Induction Motor with Varying Secondary Resistance

It may be noted, at this point, that in reversing a wound rotor motor, only the primary leads need be interchanged. The rotor circuits are entirely independent and are related to the primary only through the medium of the revolving field. The rotor circuits are self contained closed circuits, their own phase relations are fixed by the relations of the rotor windings. They will function equally well with the revolving field rotating in either direction around the stator bore.

Reversing duty may be successfully handled by specially designed squirrel cage motors, having high rotor resistance. The control comprises a primary switching device for reversing connections, together with means for supplying reduced primary voltage during reversal and acceleration. This type of control is little used except where simplicity of wiring is of advantage. An example of this kind may be seen in the case of traveling cranes.

To Control the Direction of Torque

The torque of an induction motor is ordinarily exerted in the direction that the revolving field rotates. If the load overhauls or tends to drive the motor above synchronous speed the motor becomes an induction generator and exerts a negative torque against the direction of rotation and against the revolving field. If a motor be "plugged" by reversal of the primary loads while the rotor is in motion, the direction of rotation of the field is reversed. The motor exerts a negative torque against its motion until the rotor comes to rest following which it immediately reverses and tends to accelerate in the direction of the revolving field.

Dynamic braking, which consists in providing a negative or a restraining torque to bring a motor to rest, cannot be accomplished with the induction motor as simply as with the direction current motor. It is accomplished by disconnecting the motor primary from the alternating power and exciting the primary winding with a low voltage direct current. This may be obtained from a suitable direct current source or from an exciter connected with the motor. The effect is to create a stationary magnetic field in the stator bore. As the closed circuited rotor revolves through this field a voltage is generated within it, setting up currents which react to produce a torque opposing rotation, through simple generator action. The stronger the fixed flux the greater the braking torque. The lower the resistance in the rotor circuit, the greater the current flow and the greater the braking torque.

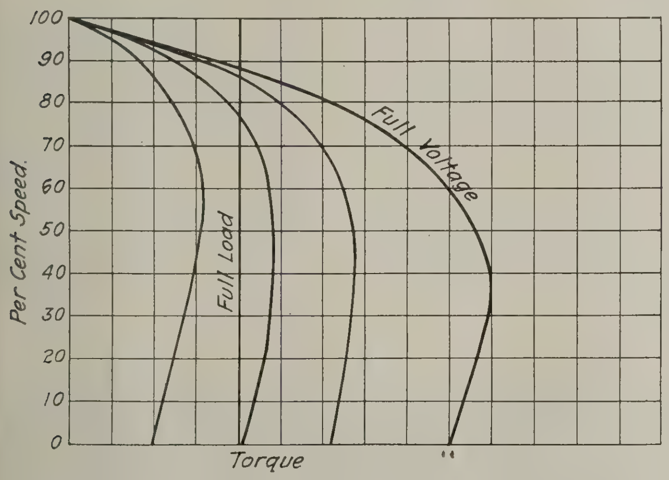


Fig. 7. Speed-Torque Curves, Varying Primary Voltage

To Control the Speed of Rotation

The speed of rotation of a synchronous motor is constant and cannot be varied except through a variation of frequency of the circuit from which the motor is operated.

The induction motor is also primarily a constant speed machine. It does not lend itself to speed adjustment so well as the direct current motor. For a restricted range of applications the speed may be so controlled as to meet the requirements of the drive.

It is possible to vary the speed of an induction motor by varying the frequency of the circuit upon which it operates. This is not feasible, however, as any material change in frequency affects the performance of the motor. An increase in frequency reduces the torque. A decrease in frequency tends to overheating. These effects may be overcome if changes in the voltage or connections be made to adapt the motor to the change in frequency. As motors are commonly operated on fixed frequency circuits this method is not feasible for any extensive application.

The rate of rotation of the revolving field of an induction motor is determined by the number of poles per phase in the stator or primary winding. By changing the coil connections the number of poles per phase may be doubled. The synchronous speed is then halved. In some motors two primary windings are provided in the stator, wound to give a different number of poles. The synchronous speed of the motor then depends upon the winding used. These so called "multi-speeds" motors are usually of the squirrel cage type. They then require a reduced potential starting device and some type of throw-over switch for changing primary connections. If the motors are of the wound rotor type, both primary and secondary connections must be changed. A rather complex throw-over switch is then required, together with means for varying the secondary resistance.

The speed regulation of an induction motor depends upon the resistance in the secondary circuit. The greater the secondary resistance and the greater the "slip" below synchronous speed with a given load. By introducing resistance in the secondary circuit of a wound rotor motor a range of speed down to 30 to 50 per cent below synchronous speed may be obtained. The characteristics are analogous to those of the direct current motor with armature control. The controller may be of any type capable of adjusting the secondary resistance. Since the motor speed, for a given value of secondary resistance, varies with the load, the speeds may be called variable rather than adjustable. This type of motor and speed control are suited only where the load is comparatively steady, where speed regulation is not important or where continuous manual adjustment is possible. In proportioning the resistance it is necessary that the load characteristics be known so that the proper amount of resistance may be supplied to obtain the desired speed range. In many cases the load decreases as the speed decreases, requiring relatively higher resistance to secure the desired speed reduction.

The slip of an induction motor under load varies approximately inversely as the square of the applied primary voltage. It is therefore possible to control the speed of squirrel cage induction motor by changing the primary voltage applied at its terminals. Standard squirrel cage motors are not suited for this work as their torque, with reduced voltage, is comparatively low. Specially designed motors, having low magnetic leakage and high rotor resistance, may be successfully controlled by this method over a limited speed range. The characteristics are similar to those secured by secondary resistance control, the speed varying with change of load. The amount of slip, with a given load, is varied by changing the primary voltage. This may be done by transformers with taps or it may be accomplished by means of primary resistance.

Inasmuch as motors adapted for this method of speed control must have a comparatively high rotor resistance, it follows that, even with full primary voltage, there will be considerable slip. Motors of this type will run at 85 to 90 per cent of synchronous speed under full load with full primary voltage. Figure 7 shows the characteristics obtained by this method at different values of primary voltage. At full voltage the slip is 11 per cent at full load.

Due to the high rotor resistance the secondary losses in a motor of this type are comparatively high. The motor must therefore be conservatively rated or used only for intermittent duty. The main advantages are in simplicity of wiring and absence of collector rings and brushes. Induction motors may be operated in series-parallel or cascade to provide a selection of speeds. In this arrangement one motor must be of the wound rotor type. The second motor may be connected to the secondary of the first motor. If both motors are connected for the same number of poles, operation in series or cascade will give a half speed point. The motors may also be operated singly or in parallel to give full speed. The control for a cascade set is similar to that for the individual motors with additional switches for connecting the secondary of the first motor either to resistance or to the primary of the second motor.

The speed of a wound rotor induction motor may be increased or decreased over a range from about 30 per cent above to 30 per cent below synchronism by connecting in the secondary circuit, auxiliary machines which introduce a counter voltage and govern the "slip" of the rotor. The control for installations of this type is a combination of that for the individual units and it comprises a means for starting the main motor by means of a secondary resistance together with an arrangement for throwing the secondary connections onto the auxiliary machines. The switches and rheostats for controlling the auxiliary machines are also included.

More Electrically Driven Ships

The Navy has recently announced the award of a number of new contracts for electrical machinery to propel the new battle cruisers and battleships.

The battle cruisers are to have a displacement of about 44,000 tons, a maximum speed of 34 knots and fractional speeds at which the economy will be very good. To achieve this high speed will require about 180,000 hp. per ship. This power will be derived from four large steam turbines, each driving a 40,000-k.v.a. 3-phase 5,000-volt generator at 1,835 r.p.m. There will be four propeller shafts on each of which will be mounted two 3-phase induction motors of 23,000 hp., each having 22 poles and running at 331 r.p.m. These motors are designed to operate also with 44 poles giving 6,800 hp. at 170 r.p.m., the condition for half speed.

The new battleships are larger than the "New Mexico," being designed for a displacement of 43,000 tons and require 60,000 hp. to drive them at their contract speed of 23 knots. The power for the battleships will be derived from two turbine-driven electric generators rated at 22,000 k.v.a., 2-phase, 5,000 volts, 1,800 r.p.m. There will be one induction motor on each of the four propeller shafts, each motor rated as 15,000 hp. at 225 r.p.m. with 16 poles. For fractional speed running the motors will be arranged with 24 poles thus giving 3,600 hp. at 150 r.p.m.

The contracts for the power plants for these ships have been awarded to the General Electric Company and the Westinghouse Electric & Manufacturing Co., respectively.

* * *

Photo from International Film Service

Railway Bridge and Train in the Austrian Alps

Photo from International Film Service

A Mountain Railway in Switzerland

The Maintenance of Interior Lighting Systems*

Some One Should Always Be Responsible For Cleaning Lamps, Reflectors, Walls and Ceiling.

By Ward Harrison and J. R. Colville.
Engineering Department, National Lamp Works, Cleveland, Ohio.

DIRTY reflectors, walls and ceilings darkened by smoke and dust, blackened lamps left in service as long as they continue to burn, empty sockets, unobserved burn-outs and replacements with lamps of wrong size or improper voltage rating are prime causes of inadequate illumination.

An office lighting installation recently examined is a case in point. The installation consisted of indirect units and had been in operation two and one-half years. The ceiling had been painted a flat white and the walls finished in a light buff. At the time the installation was made the intensity of illumination was adequate.

The engineer who investigated this installation, in response to a complaint, found that the average illumination intensity on the desk tops was 2.7 foot-candles—unquestionably too low for office work.

(1) The reflectors had been wiped out at fairly regular intervals, but were nevertheless taken down and thoroughly washed. The illumination jumped at once to 3.7 foot-candles—an increase of over 35 per cent arising from washing what appeared to be fairly clean reflectors.

(2) The lamps had been in service for more than two years. Furthermore, it was found that their rating was several volts higher than the average voltage of the circuit. When new lamps of the proper voltage rating were substituted the illumination increased to over 5 foot-candles.

(3) The ceiling in this office had originally been finished with a paint which had been tested and found to reflect 75 per cent of the light striking it. In two and one-half years it had become so soiled through soft-coal smoke that a comparison with paint samples whose reflection factors were known demonstrated that it was reflecting but 50 to 55 per cent of the incident light. The side walls had depreciated in like proportion. Refinishing the office in its original tone further increased the illumination by about 40 per cent, or to a total of over 7 foot-candles.

Here is a case where failure to observe simple maintenance requirements resulted in an intensity of 2.7 foot-candles where an intensity of over 7 was being paid for.

There are two methods by which the maintenance of any selected value of intensity can be assured—first, by allowing for an enormous depreciation in the light and consequently using much larger lamps than would ordinarily be considered necessary; second, by maintaining the the system properly and allowing for reasonable depreciation. The second, or generally practical, method involves:

1. The use of a depreciation factor, or factor of safety, in the original design of the system to insure adequate illumination when the system has depreciated a normal amount.
2. The cleaning of lighting units at frequent, regular intervals.
3. The replacement of lamps which have become blackened in service by abnormally long life.

---

*Electrical World, Jan. 24, 1920.

4. The use of lamps of the correct voltage rating for all replacements.
5. The refinishing of ceilings and walls at reasonable intervals.

The Depreciation Factor in Illumination Design

The purpose of the depreciation factor is to insure adequate illumination when the installation shows maximum depreciation under the system of cleaning adopted. For example, where units are cleaned and inspected every three weeks the illumination just before cleaning may be 15 per cent lower than immediately after. Furthermore, the ceiling and walls will gradually become darkened, so that the illumination at the end of a year, even with the lighting units thoroughly cleaned and the lamps in excellent condition, will be materially lower than when the installation was new. In order to insure that the illumination will at no time be inadequate, it is necessary to add a suitable amount to the intensity considered desirable and design for this larger amount initially.

How dust and dirt destroy the effectiveness of lighting units is strikingly shown in Fig. 1. A point which is not apparent from the curves but which should be mentioned in this connection is that a dirty installation is likely to be more objectionable from the standpoints of glare and density of shadows than one which is clean. Glare is somewhat a matter of brightness contrast, and a bright bulb against a dirty reflector or a bright unit against a blackened ceiling may appreciably accentuate glare. The density of shadows depends, among other things, upon the areas of the light sources, and where reflectors are dirty, their contribution of diffused light is lost and dark, sharp shadows result.

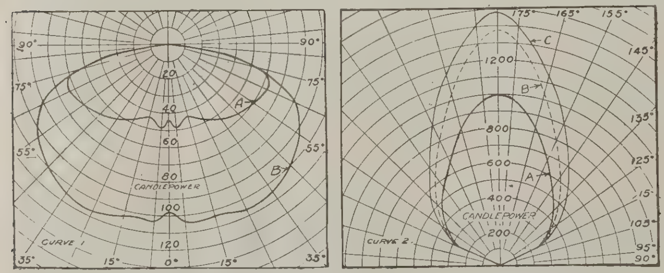


Fig. 1. Dirt Destroys the Effectiveness of Lighting Equipment

A—Reflector Dirty
B—Reflector Clean

A—Reflector Dirty
B—Reflector Wiped Out
C—Reflector Washed

How large an amount should be added to the intensity considered adequate, or, what amounts to the same thing, by how large a factor the intensity considered adequate should be multiplied, to insure proper illumination at all times, depends upon the specific conditions surrounding any particular installation. The data presented in Table I, taken from the lecture course presented in 1916 under the joint auspices of the Illuminating Engineering Society and the University of Pennsylvania, give specific figures for depreciation due to dirty lamps and reflectors. In general, when installed in relatively favorable locations, open-reflector units show a depreciation which ranges from 10 to 25 per cent in four weeks' time. Where excessive smoke and dust are the rule, the depreciation over the same period may be as high as 40 per cent. The depreciation of ceilings and walls depends not only upon the characteristics of the location—*i. e.,* whether clean or dirty—but upon their original color as well. The only factor which is not affected by location is the depreciation of lamps with burning. Gas-filled lamps average about 95 per cent of their initial light output throughout life; the output at the end of rated life is usually about 92 per cent of the initial output, and where there are only one or two lamps in a room lamp depreciation must be based upon this figure rather than upon the average output. While the total depreciation of lighting systems over a given period will, of course, vary widely, experience has shown that a factor of 1.2 for very clean locations and very clean operations (16 2/3 per cent loss) and a factor of 1.5 for dirty locations and relatively dirty operations (33 1/3 per cent loss) may be used with assurance of satisfactory results, provided, and this is of the greatest importance, that a schedule of regular and frequent cleaning be adopted and adhered to.

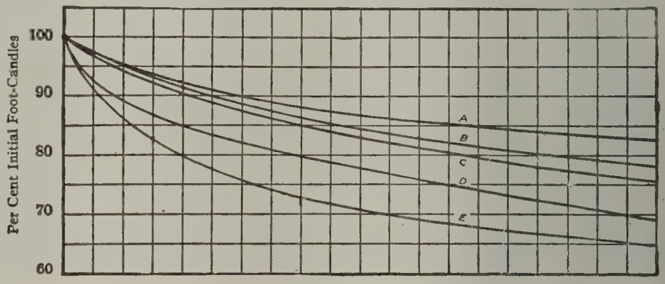


Fig. 2. Effect of Collection of Dust on Lamps and Reflectors

A—Dome enameled steel C—Dense Opal glass
B—Bowl enameled steel D—Prismatic glass
E—Light Density Opal glass

TABLE I—LOSS OF LIGHT BY ACCUMULATION OF DIRT*

Authority and Reference	Conditions and Surroundings	Lamps, Globes and Reflectors	Per Cent Period Covered by Tests	Total Decline for Period
Durgin and Jackson *Trans.* I.E.S., 1915, p. 707.	Downtown Chicago Office building dustiest rooms	Semi-indirect dense bowls and tungsten lamps.	Three weeks	26
Aldrich and Malia, *Trans.* I.E.S., 1914, p. 112.	Office building in Chicago stock yards.	Prismatic reflectors, satin finish, and tungsten lamps direct.	Twelve weeks	25
Aldrich and Malia, *Trans.* I.E.S., 1914, p. 112.	Office building in Chicago stock yards.	Mirror reflectors and tungsten lamps indirect.	Nine weeks	25
Edwards and Harrison, *Trans.* I.E.S., 1914, p. 176.	Office corridor suburban district, Cleveland.	Inclosing prismatic.	Eight weeks	11

*"Illuminating Engineering Practice," 1916, Illuminating Engineering Society—University of Pennsylvania.

The Different Phases of Maintenance

Cleaning—The curves of Fig. 2 are of interest as showing the relative rapidity with which various systems of open-reflector units depreciate owing to dust and dirt. The values from which these curves are plotted were obtained by measuring the illumination intensity at the work. In this way the effect on the resulting illumination of deposits on the inside and the outside of the reflecting and diffusing surfaces is correctly weighted, a result not obtained when units are measured in a photometer for total light output.

Reference to curve 2 of Fig. 1 will show that there is a great difference between merely wiping out a unit and washing it thoroughly. On the average, wiping out has about two-thirds the effect of a thorough washing. Obviously, in arriving at any cleaning schedule, the care with which the work is to be done is an important consideration.

A device has recently been developed which will be found extremely useful in the proper maintenance of a lighting installation. This device is known as a foot-candle meter, for it measures the illumination at the work directly in terms of foot-candles. The instrument is shown in Fig. 3. With it the illumination can be read directly from the scale without computations or adjustments. In one large establishment where the superintendent uses a foot-candle meter systematically as a check on his maintenance department, readings of illumination intensity are taken at regular intervals at fixed stations throughout the plant. These readings are recorded in such a way that the successive readings are readily comparable. When any inconsistency appears in the records an investigation is made and the proper remedy applied. The intensity in this establishment is never allowed to fall below 6 foot-candles without immediate correction. By measuring light actually delivered to the work the foot-candle meter automatically reveals the combined effect of all possible causes of depreciation. Ignorance of the magnitude of depreciation has often been the cause of inadequate maintenance.

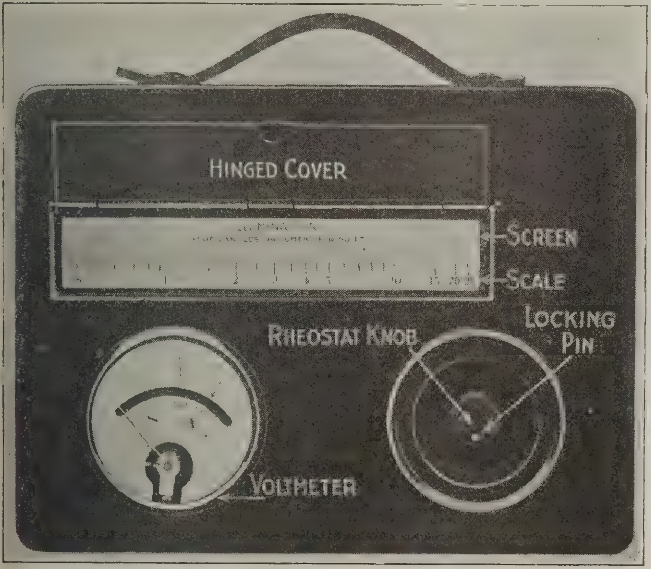


Fig. 3. Foot candle Meter

As has been pointed out, the importance of the factors affecting the rate of depreciation of a lighting system is largely dependent upon local conditions, and it is difficult to formulate cleaning schedules which will be generally applicable. The schedules suggested in Table II may be used as a basis for formulating a schedule adapted to specific conditions; however, a man with a foot-candle meter is the best judge of individual requirements.

It is of the utmost importance that the responsibility for proper maintenance of the lighting system be definitely assigned. Experience proves that unless there is a clear understanding on this point the work is never properly handled. A definite schedule should be outlined and carefully enforced. In large industrial plants, large office buildings and the like a small maintenance department is necessary for accomplishing effective results. In smaller buildings one employee may be able to handle the work satisfactorily. It is significant that several of the more progressive window-cleaning companies have established the cleaning of lighting equipment as a part of their regular service, and this plan has the advantage that the work is done by trained men.

It is unfortunate that in the design of lighting systems more attention is not given to accessibility for cleaning. Yet even where careful thought is given to this factor it is frequently necessary because of other considerations to place units where they are very difficult of access. In many industrial plants, such, for example, as steel mills, units can be reached for cleaning only from the traveling crane, and the fact that the crane is likely to be in service twenty-four hours a day six days in the week complicates the maintenance problem. Where such conditions exist, it is advisable to go over the system every week end rather than to attempt to operate a five-day or a ten-day cleaning schedule. In some cases it will be found practicable to substitute clean units for dirty ones throughout a section of a plant, clean the dirty ones, and substitute them for others in another section, etc. This can be done readily by using standard devices for connecting to and disconnecting from the circuit.

TABLE II—SUGGESTED CLEANING SCHEDULES

Where direct-lighting systems are used—*i.e.*, where there are no reflecting or diffusing surfaces concave upward to invite dirt accumulation—the interval of cleaning should be about as follows:

Characteristic of Location	Intervals in Days if Units Are Wiped Out*	Intervals in Days if Units Are Thoroughly Washed
Very dirty	3	5
Dirty	7	10
Average	15	20
Clean	30	40

Where open-semi-indirect or totally indirect units are used:

Characteristic of Location	Intervals in Days if Units Are Wiped Out*	Intervals in Days if Units Are Thoroughly Washed
Dirty	5	7
Average	10	15
Clean	20	30

*Washing every third or fourth interval assumed.

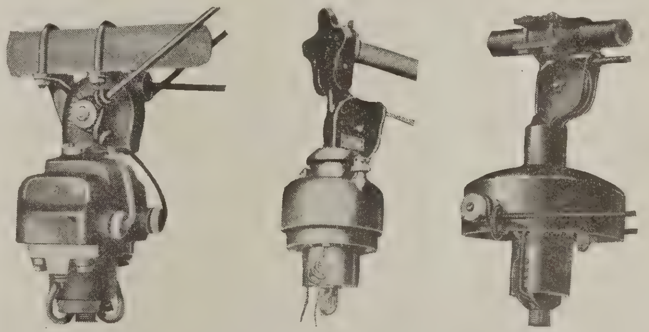


Fig. 4. Cut-out Hangers Facilitate Cleaning

Where units are so placed that their proper maintenance involves considerable difficulty or perhaps danger to the one who looks after them, the investment in some form of disconnecting hanger which permits the units to be lowered to the floor is advisable. Several types of such hangers are available and their use will be found to go a long way toward insuring proper maintenance. Women, or men who are no longer able to work safely high above floor level can sometimes be employed advantageously where the work is simplified in this way.

Some units are, of course, easier to clean than others, but, with the exception of certain types built up of plaster* or composition and those employing polished metal, all require a thorough washing at least as often as every third or fourth cleaning period. A small stiff brush will often be found to expedite the work. Warm water and soap appear to be about as effective as the chemical cleaners for general use, although where the reflectors become stained, as by exposure to fumes, the latter facilitate the work. Any prepared cleaners which give satisfactory results in the bathroom of a home may be used without fear of their damaging the reflecting surfaces of lighting units. Where mirrored reflectors are washed, special attention should be given to avoiding injury to the backing.

Replacement of Lamps.—The manufacturers, through improvements in lamp making, have succeeded in producing lamps in which the candlepower is well maintained throughout life, and blackened bulbs are continually decreasing in number. However, individual lamps show considerable variation from the average performance, and where inspection shows a bulb to be considerably darkened the lamp should be replaced with a new one. Vacuum lamps require more careful inspection in this respect than gas-filled lamps.

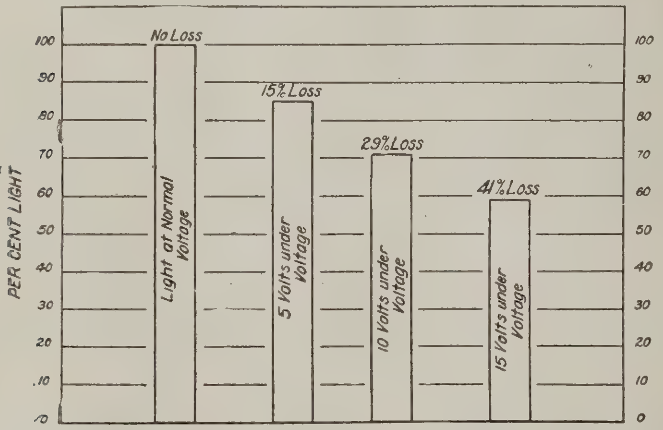


Fig. 5. Loss of Light Due to Low Voltage—Based on 115-volt Tungsten Lamp.

While it can be shown that it is cheaper to replace a blackened lamp with a new one under most operating conditions, the consideration of greater importance is the fact that blackened bulbs absorb light which is needed upon the desk tops, machines or counters, as the case may be. The inspection of lamps for this cause of lighting depreciation is simple, and it should be done at each cleaning period.

The cleaning of any unit should not be considered complete until it has been lighted to insure that the lamp or lamps operate. Where several lamps are used in an indirect or dense semi-indirect bowl, one or more may fail without the effect in the illumination being at once apparent unless the maintenance man examines the fixture for this possibility. On the other hand, where a single large lamp is used in such bowls a lamp failure is at once observed. The cleaners should carry a supply of lamps of the proper size with them so that a burned-out bulb may be replaced immediately.

Voltage Rating.—Incandescent electric lamps are rated for a given light output at a certain voltage. On a lower voltage a lamp will give less light and on a higher voltage more light. This is generally understood, but few appreciate that the variation in light output is several times as great as the variation in voltage. The chart of Fig. 5 shows the relation between light output and voltage as obtained by exhaustive tests on many groups of lamps. A difference between rated voltage and operating voltage of a few per cent is accompanied by a percentage difference in light output about three and a half times as great.

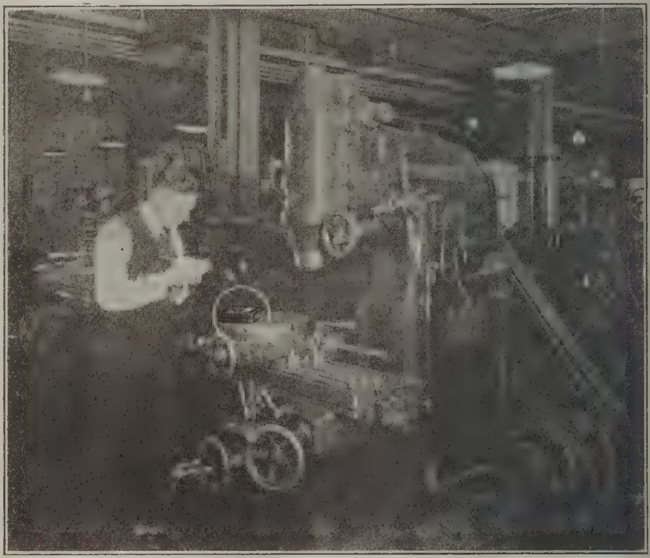


Fig. 6. Foot-candle Meter Reveals Possible Causes of Depreciation.

Refinishing of Ceiling and Walls.—How frequently an interior requires refinishing depends upon: the type of lighting, whether direct, semi-indirect or totally indirect; the nature of the finish employed; the characteristics of the location, whether relatively clean or dirty, and, in less degree, upon the color of the finished surfaces.

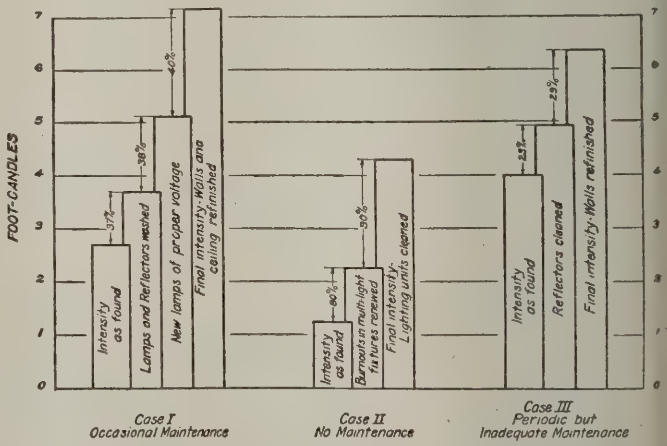


Fig. 7. Tests of Semi-Indirect and Indirect Lighting Systems Illustrate Necessity for Regular and Adequate Maintenance.

Reflectors in a direct-lighting system themselves turn light into a downward direction and make the effectiveness of the system less dependent upon reflection from the ceiling and walls than where other units are used. Inclosing units amid light-colored surroundings produce a distinctly pleasant brightness; amid dark surroundings they furnish much less light and frequently are excessively glaring. Again, semi-indirect and totally indirect systems depend essentially upon good reflection from the ceiling, and to a less extent from the walls, tor their effectiveness.

---

*The reflecting efficiency of plaster or composition can best be renewed by rubbing with sandpaper or a stiff wire brush.

Fortunately, considerations of appearance often dictate the refinishing of a soiled and gloomy interior where the expenditure from a lighting standpoint alone would not have suggested itself. However, ceilings and walls, like other reflecting surfaces, lose much of their effectiveness before the accumulation of dust has reached the point where the surfaces appear badly in need of refinishing. For this reason it should be the duty of the maintenance department to ascertain the condition of the walls and ceiling and to see that they are kept in a good reflecting condition.

A white paint or plaster surface absorbs less light than any other interior finish. Yellowish or warm-toned paints are considered desirable in many cases on account of the cheerful, pleasant atmosphere created. Such tones reflect a larger proportion of artificial light striking them than blue tones, although the latter may appear at first glance equally light. The reason for this is that the light from the ordinary incandescent lamp contains a higher percentage of yellow and red rays than blue rays, and a surface of a tone other than white reflects a greater proportion of the rays of its own color than of another color. This is the basis of the common recommendation that where a white paint is not wanted a paint of light-cream tone may be used without bringing about a marked sacrifice in lighting effectiveness.

The mistake should not be made of using paints of a yellowish tone for ceilings with daylight lamps in indirect or semi-indirect fixtures, for the yellow tones would not only reduce the efficiency of the installation but would destroy largely the daylight effect sought. Experiments have shown, however, that the color of the portions of the side wall near the floor has no material effect upon either the color quality or the amount of illumination.

Alternating Current Theory and Practice

A Brief Practical Review of Basic Principles Prepared for Railroad Electrical Workers

By O. C. Callow

III—Two and Three-Phase Machines

The two-phase alternative current generator can be explained in a similar manner to the single-phase generator in the preceding article, by means of a simple machine as in Fig. 1. This two-pole machine has two coils wound on the drum, each having two conductors; AB and CD making one coil, with the ends A and D connected to one set of slip rings E and F, and the conductors G, H, J and K, making up the second coil with the ends G and K connected to a second set of slip rings L and M. It will be noted that the conductors are spaced 90 degrees from one another, while those making one coil are 180 degrees apart, having a pitch equal to the pole pitch.

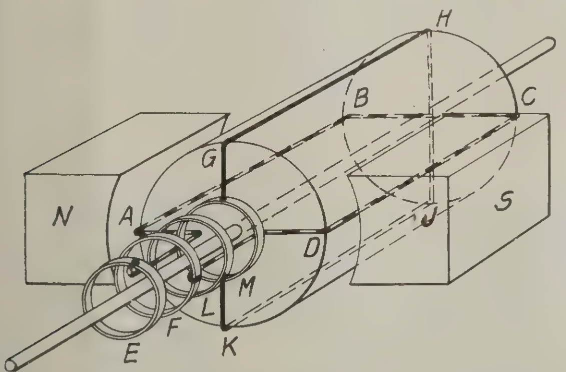


Fig. 1. A Two-Phase Generator in its Simplest Form

Consider the voltage generated in each coil when the drum is rotated in a clockwise direction and at the instant that they are in the positions shown in Fig. 1. Conductor AB will be cutting the maximum lines of force flowing from the north pole and conductor CD the maximum flowing into the south pole. Maximum voltage will therefore be flowing out of slip ring F, through the external circuit and back at E. Conductors GH and JK will be equally distant between the north and south poles, but will not cut the lines of force and therefore generate no voltage. As the drum rotates, these conditions are reversed, the voltage in $ABCD$ drops to

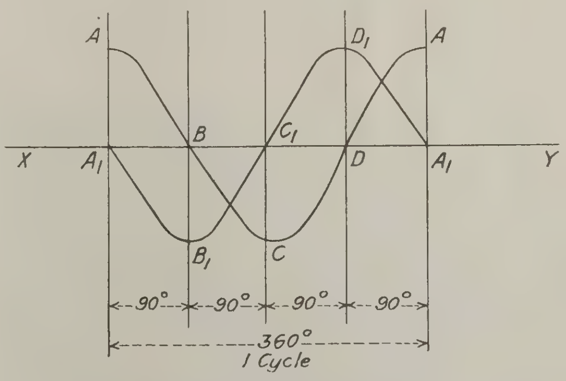


Fig. 2. Curves Showing the Rise and Fall of the Voltage in the Coils of a Two-Phase Generator

zero after a quarter of a revolution or 90 degrees and that in *GHJK* builds up to maximum. Voltage will now be flowing out of slip ring *M* and back at *L* through the second external circuit. If the rotation is continued, it will be found that at the end of half a revolution or 180 degrees, maximum voltage will be flowing out of *E* and back at *F* while the voltage at *L* and *M* is at zero. At three quarters of a revolution or 270 degrees, the voltage at *E* and *F* will be zero and maximum voltage will be flowing out of *L* and back at *M*.

The above results can be shown graphically, as in Fig. 2, using the line *XY* to represent zero voltage, with positive values above and negative below. The degrees through which the conductors turn are shown along *XY*. Commencing at the first position considered above, with *AB* in the center of the *N*-pole, it was found that maximum voltage was flowing out of slip ring *E*. The value of the voltage is shown by the point *A* in the positive direction. At the same instant it was shown that the voltage in the other coil was at zero, this point A_1 is shown on the line *XY* on the same vertical line as *A*. The next position considered was after the drum had traveled through 90 degrees. In this position the voltage in the *ABCD* had dropped to zero as shown by the point *B*, while the voltage in the *GHJK* was at maximum as at point B_1. Since the conductor *GH* was cutting lines flowing into the *S*-pole, this voltage will be in the opposite direction to that generated in *ABCD* and is therefore shown in the negative direction below *XY*. By considering the values of the voltage at 180 degrees, the points *C* and C_1 are obtained, the voltage *ABCD* being at maximum in the negative direction and the voltage in *GHJK* at zero. At 270 degrees the point *D* is obtained at zero and D_1 at maximum in the positive end of one revolution and the points are the same as at the beginning.

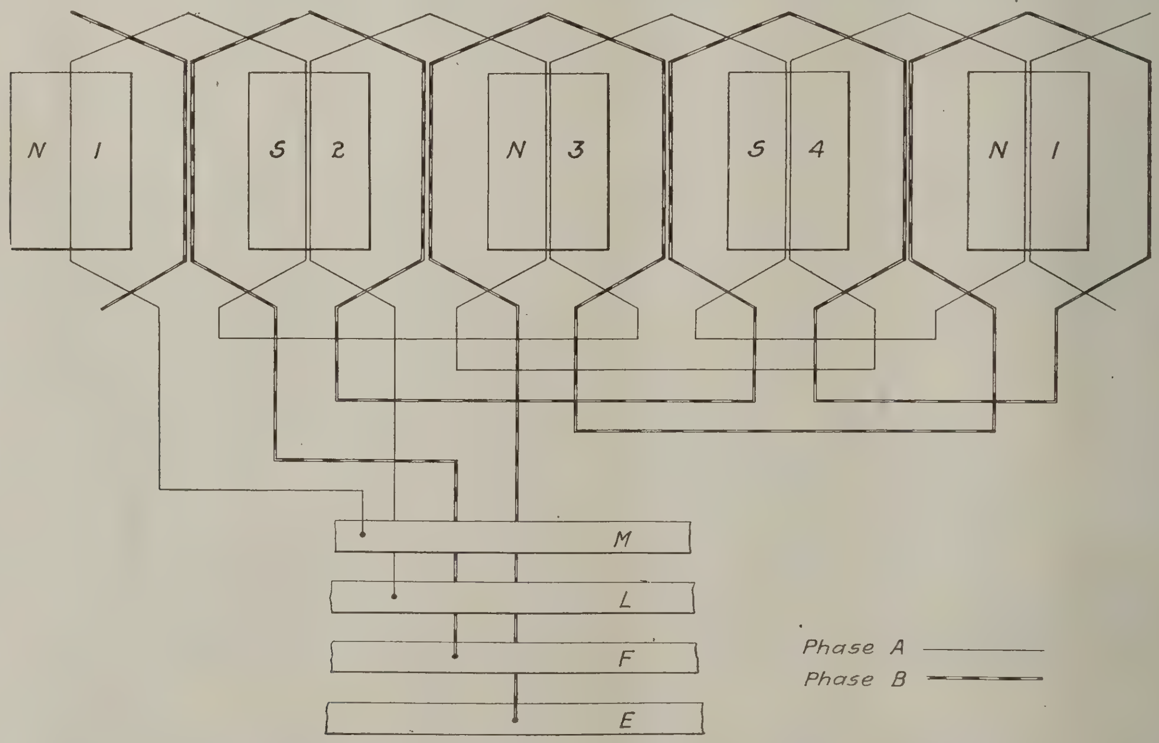


Fig. 3. A Developed View of a Four-Pole Two-Phase Generator, Having One Coil to a Group and a Coil Pitch Equal to the Pole Pitch

It is seen from the foregoing that two distinct single-phase circuits are produced in the two-phase generator. Referring to Fig. 2 it will be noted that the curve *ABCD* is always 90 degrees ahead of the curve $A_1B_1C_1D_1$. It is therefore said that the phases of a two-phase generator are 90 degrees apart.

It will be noted that one phase completed one cycle per revolution. During the same time the second phase also completed one cycle. Therefore the total cycles produced in one revolution will be only one, being equal to the number of pairs of poles as in the single-phase machine.

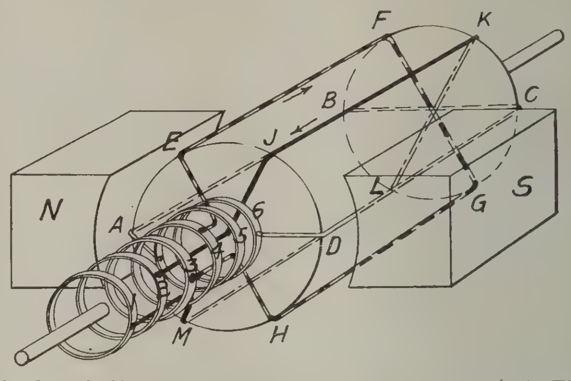


Fig. 4. Sketch Showing Arrangement of Coils On a Simple Three-Phase Generator

The windings of the two-phase generator are similar to the winding of the single-phase generator shown in the preceding article, there being two single-phase windings entirely independent from one another, each connected to its own slip rings. Fig. 3 shows a developed view of a four-pole two-phase generator, having one coil to a group and a coil pitch equal to the pole pitch. It will be noticed that the first conductor of *A*-phase is under the center of the first north pole while the first conductor of *B*-phase is midway between *N*1 and *S*2 which is similar to the machine shown in Fig. 1. This relation is kept up all through the winding. In practices several coils would be connected in each group. Each of these groups would be connected in the same manner as the single coil shown in Fig. 3.

The next type of generator to be considered will be a three-phase machine. This can be explained by means of a simple two-pole machine with three single phase windings and six collector rings as shown in Fig. 4. The windings consist of three coils, each coil being connected to a slip ring. The coils are 60 degrees apart, while the conductors of each individual coil are 180 degrees apart. Consider the voltage and current generated in the conductors of the machine shown in Fig. 4, when the drum is rotated in a clockwise direction. The conductor *AB,* being in the center of the north pole will generate maximum voltage. Voltage and current will flow to the external circuit out of the slip ring 6 and back at 5. The voltage in *EF* will be approaching zero, but will be in the same direction as in *AB,* since it is still cutting lines of force flowing from the north pole. Voltage and current will therefore be flowing out of slip ring 3 and back at 4. Again, the voltage in *JK* will be building up from zero, but in the opposite direction, as it cuts lines of force flowing into the south pole. Voltage and current will flow out of slip ring 2 and back at 1.

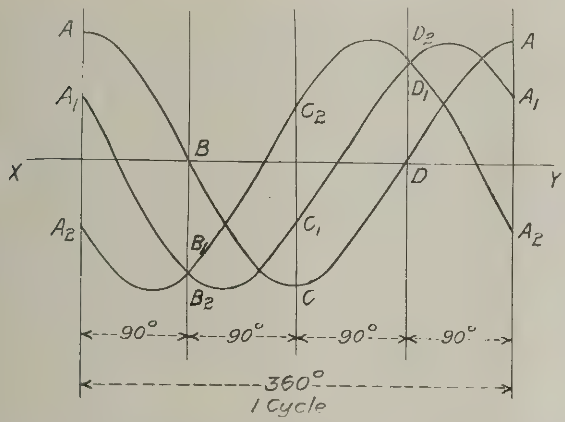


Fig. 5. Curves Showing the Relation of the Voltage in the Different Phases of a Three-Phase Generator

If the generated voltage be shown graphically as in Fig. 5 arranged with the line *XY* representing zero voltage. The points A, A_1 and A_2 will be found to correspond to the voltages in the three conductors as shown in Fig. 4. As the rotation is continued it will be seen that the voltage in *AB* falls off, until it reaches zero, after the drum has revolved 90 degrees, this gives the point *B* on the curve. The voltage in *EF* falls at zero and builds up in the opposite direction reaching about half-strength, giving the point B_1 on the curve. The voltage in *JK* builds up to maximum and falls off again to about half strength, giving the point B_2 on the curve. If the drum is rotated another 90 degrees making half a revolution, we find that the voltage in *AB* builds up from zero to maximum, but on the opposite or negative direction, giving the point *C* on the curve. The voltage in *EF* rises to maximum and falls again to half-strength, still in the negative direction, giving the point C_1 on the curve. The voltage in *JK* continues to fall, passes through zero and builds up again in the positive direction, making the point C_2 on the curve. If the drum is again turned through 90 degrees, making a total of 270 degrees, the points, D, D_1 and D_2 are obtained. At the end of one revolution or 360 degrees, the voltage values will be found to be the same as at A, A_1, and A_2. A complete cycle will have been produced by each phase, which will continue indefinitely, each phase following the other 60 degrees apart.

Each of the three phases produced a complete cycle in one revolution of the drum. Inasmuch as they were all produced during the same period of time they are not additive. The total cycles produced by a three-phase generator in one revolution will therefore be equal to the number of pairs of poles which the machine contains, in a similar manner and for the same reasons as have been explained previously. The formula

$$\text{Rev. per min.} = \frac{\text{cycles per second x 60}}{\text{No. of pairs of poles}}$$

can therefore be employed for the three-phase machine, when it is required to determine the correct speed to drive it to give a known frequency per second.

* * *

Photo from International

The Krupp Works Celebrates

Photo Copyright by Underwood & Underwood, N. Y.

A Scene in Lima, Peru

Employing Motor Trucks in Trap Car Service*

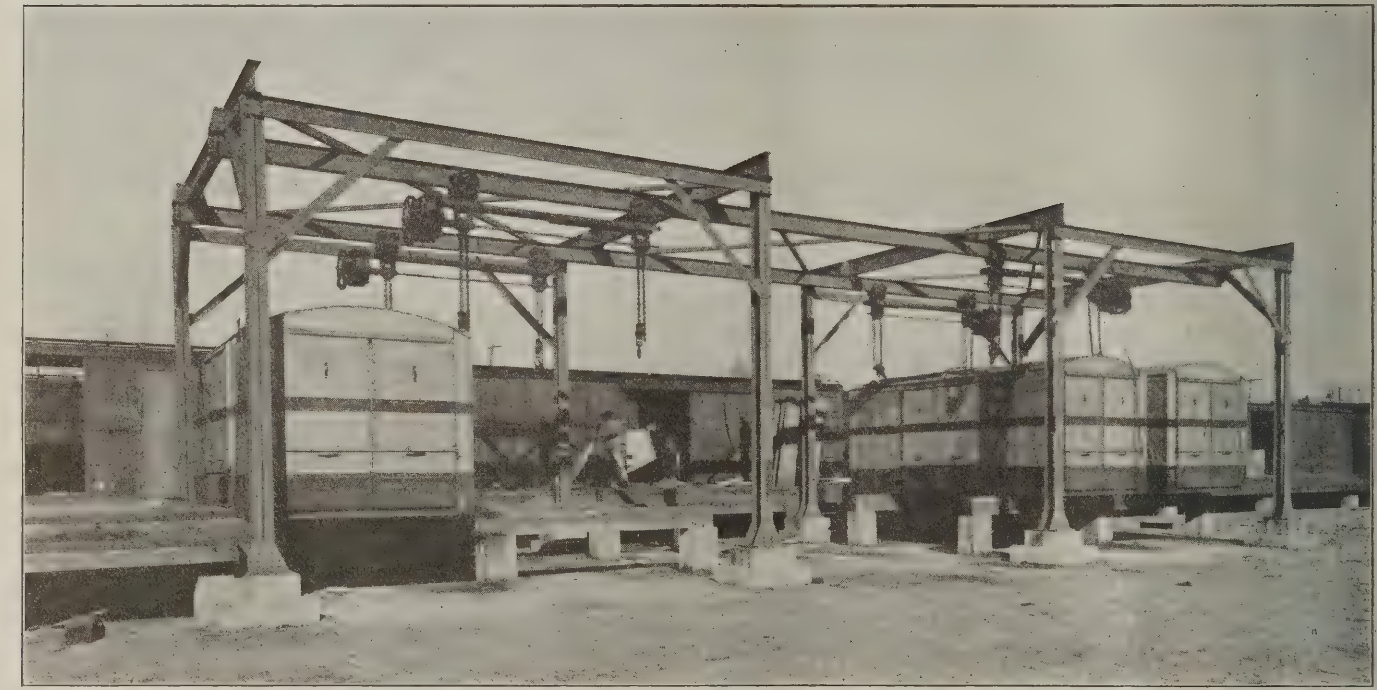
Use of Street-Going Vans at Cincinnati Effects Great Reduction in Rail Terminal Congestion

By B. F. Fitch
President, Motor Terminals Company, New York.

THERE IS PRACTICALLY no limit to what the rails will carry, if cars, when consolidated in trains, are at once started and kept continuously moving; therefore, it is logical to charge inadequate terminal facilities with the major portion of the box car's tonnage deficiencies. Inadequate terminals alone are not responsible for this nor can either the railroads or the public be censored for using box cars illegitimately in lieu of other facilities for short-term storage. The prime trouble is that, as an operating necessity, in absence of other facilities, box cars have been assigned to a service for which they were never intended, and this makeshift usage has complicated switching interchanges at all terminal points to the detriment of high mileage efficiency of all cars.

Our national transportation practice and trade influences of the traffic do not permit of any radical terminal changes. Any revolutionary attempts along this line might embarrass our production resources as greatly as a change in the monetary basis. Therefore, evolutionary improvements only can be considered. To demonstrate the fact that railroad transportation has outgrown railroad terminals, it is interesting to note that from outer classification yards to pier station delivery at New York the cost to carrier is not less than $3.50 per ton and, similarly, at Philadelphia, not less than $2.50 per ton, or a joint terminal cost of $6 per ton. Whereas, the main line haul between these two terminals, if estimated at a maximum cost of 6 mills per ton mile, suggests a transportation cost of 60 cents versus terminal costs of $6.

With unlimited financial resources the engineering talent of the country can quickly solve the problem. Ideal joint terminals at a cost of $50,000,000 to $500,000,000 are possible in all of our principal centers, but who will assume the responsibility of such abnormal financing? Each present terminal layout must be continued substantially as at present. Conservatism recommends no radical changes, but demands evolutionary changes to bring about better conditions.



General View of Baltimore & Ohio Norwood Sub-station

Despite opportunity for improvements, the industrial trap car and the intro-terminal trap car will apparently always complicate terminal interchanges to the detriment of switching refinements. Terminal operating economies will be in direct ratio with the decrease in the number of interchange switching combinations. So apparently new freight stations at huge investment are no guarantee of great reductions in terminal expense, because freight station labor cost is but a small item as compared with total terminal expense.

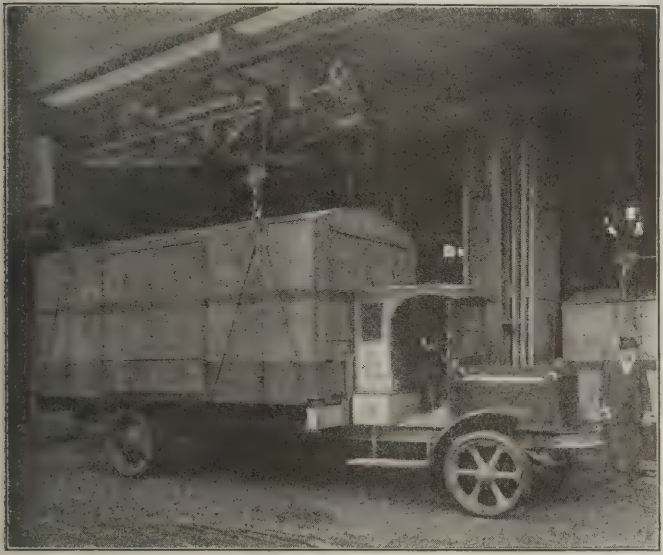
In any city with seven non-competing railroads radiating to different sections, each line receives daily some freight for each of the six connections. Numerically, this means 42 cars in transit to and 42 cars in transit

---

*Abstract of a paper read at a meeting of the Material Handling Machinery Manufacturers' Association, Waldorf-Astoria, New York, February 26, 1920. A brief description of this installation was also given by Zenas W. Cater, secretary of the Material Handling Machinery Manufacturers' Association, at the November meeting of the New York Railway Club. (See *Railway Electrical Engineer*, December, 1919, page 421.)

from, a total of 84 cars. But due to yard interchange delays these cars average a third day arrival instead of a second day arrival; hence, 252 cars are assigned daily to such service. Thus 75,600 car days are required annually.

Industrial expansion at any city with seven initial lines, has, as a rule, outgrown station facilities and railroads for economy's sake have strategically established substations along their right-of-way as traffic influences for shipments from outlying districts. Since all the freight from these outlying districts has to be brought to the main stations to be consolidated in cars for despatch from such main stations to destination points, and since all of the freight for these sub-stations comes out of main station cars on arrival, trap cars are necessary in this main sub-station service of each line. The number of cars so used is a multiple of the number of stations. If each of the seven lines has three stations, 42 cars are required, the movement delays to which are as great as connecting line cars; therefore, the wasting of an additional 37,800-car days.


Louisville & Nashville East End Freight House—Outbound Side

This explains one of the reasons for car shortage and an operating abuse which has been obsoleted by the success of a motor terminals installation at Cincinnati, Ohio. Briefly, this installation consists of overhead rails, electric cranes, electric hoists, motor trucks and a plurality of interchangeable motor truck bodies. The system of operation requires an empty body for each station movement demand of railroad on its inbound main station platform. At the larger stations there are several locations for such body settings, thereby decreasing the trucking distance for freight. As the freight comes from the cars, it is trucked to the nearest location containing a body which has been carded for any connection or any sub-station.

When loaded, these bodies are sealed and under telephone order of a joint despatcher, employed by the railroads, mechanically loaded onto trucks and thus rested over the city streets to a connection. On arrival at the outbound platform of the connecting line, the body is mechanically removed and an empty body, previously unloaded, is put onto the motor truck chassis for delivery to the inbound platform of that house, where the operation is repeated and another loaded body is forwarded in the same manner to some other freight house.

If the load happens to be to a sub-station, it remains on the platform until the despatcher is advised by the agent at the sub-station that a return load is available. Then the loaded body of inbound freight to that sub-station is forwarded and the motor truck exchanges it for the previously reported load of outbound freight to be delivered at the main station, where it is consolidated with other city freight in line cars made up daily to other destination points.

It is evident that all freight, except possibly the portion arriving during the last hour of the station operating day, whether between main and sub-stations or between main stations of the various railroads, is currently loaded and hauled out of the terminal. Previously, the movement of this freight by trap cars suffered an average of three days' delay and the shuttle movement of these individual cars over terminal rails interfered with the group movement of complete cuts of station cars. Hence, the congestion which previously made Cincinnati notorious as a check-valve in rail routings.

In May, 1917, the Cleveland, Cincinnati, Chicago & St. Louis permitted a test installation between its five main and sub-stations. The innovation was an early success, but the other roads were skeptical of its enduring efficiency. In the early months of 1918 a special committee was appointed to analyze the entire terminal and, based upon Big Four accomplishments, recommend what economies and benefits could be anticipated from completely motorizing Cincinnati's terminal. The summary of this comparative report prophesied the following:

C. C. C. & St. L. Central Avenue Outbound Station

Annual economy, $61,653.
Advance in movement of freight, 52.4 hours.
Increase in inbound platform floor area, 14.8 per cent.
Increase in outbound platform floor area in ratio with station operation.
Increase in main station trackage, 21.4 per cent.
Increase in main station realty, 122,660 sq. ft.
Release of 66,862 cars for line service, per annum.
Extension of present labor, 30.4 per cent.
Eliminating the rehandling of 86,976 tons of freight, lessens railroads liability of loss and damage

In 1919 equipment orders were entered and railroads commenced station changes and superstructure construction, but the terminal is not yet fully equipped, because of delays. However, in recent analysis of accomplishments it is proven that, due to increased operating costs of railroads, the prophesied 17.1 cents per ton economy is in practice actually a saving of 35.2 cents per ton and, therefore, the annual economies will be $126,508 instead of $61,653.

This service has proven that all widely distributed station facilities can be laced up as a unit without investment cost to the railroads, thereby giving to each and every terminal the benefits of a union freight station. The rates paid for the service are less than what interest charges alone would be on the cost of constructing a consolidated terminal. The operating program of railroads and the established perquisites of shoppers are in nowise disturbed, but the railroads at large through the influence of this current versus their past interrupted movements enjoy an increase of terminal rail, station rail and station platform facilities. This increase can be perpetually extended at minimum investment, in ratio with increasing tonnage demands, which naturally will accrue at any industrial city enjoying better shipping facilities.

Extensions are now possible in the form of rail sub-stations or off-track warehouse sub-stations by this system, and can be gradually provided as the tonnage demands warrant. There is no necessity to finance elaborate facilities to take care of accruing demands which may not develop for 50 years.

Chesapeake & Ohio Inbound Station at Fourth Street

What has been done at Cincinnati can be adapted to the varying demands of all principal terminal cities. The flexible possibilities of trucks are now clearly defined for industries having transportation facilities dependent upon rail extensions. Opportunity at each point is limited only to intelligent installations following detail analysis to establish the greatest terminal efficiencies of a carrier to meet the shipping demands of the public.

The accomplishments at Cincinnati warrant a study of the system as applied to the greatest terminal problem in the world, New York. At present the railroads monopolize approximately 30 per cent of Manhattan's piers for freight stations. Where not individually owned, the rental value of piers is out of all proportion with freight tariff returns, but a few blocks inland, realty enjoys but a fraction of bulkhead rental values. If inland joint stations, in say 12 zones, were constructed on this otherwise comparatively non-productive realty, the railroad piers could be released for shipping and station facilities could be attained by the railroads at practically no cost, because of increased rentals possible for warehouses and industrial floors above joint freight terminals.

If all roads contributing this terminal had transfer stations at their rail bulkheads or a few blocks back from the valuable waterfront of Jersey City, Staten Island and Bronx, carload and less than carload package freight could be immediately transferred from cars to motor truck bodies, which would be designated for each of these inland stations, and the freight cars thereby released for immediate reloading of outbound freight. These bodies, when loaded on trucks, would be routed over streets to the nearest available Staten Island or Jersey slip for ferrying to the Manhattan slip nearest the inland station destination, and vice versa on the return movement.

The inland station investment is a realty venture requiring no financing on the part of the railroads, because assured rental returns from upper stories will invite outside capital to furnish the station facilities in ever increasing numbers as fast as the railroads desire to contract for the use of such. In short, the motor truck, reinforced by this system, offers an opportunity to convert present transportation losses into profits for both carriers and shippers, and this opportunity does not suffer the handicap of engineering problems and long construction delays.

It is an immediately available asset, the adoption of which is not entirely dependent on concerted action by the railroads. The initial installation at Cincinnati has demonstrated the possibility of capitalizing existing economic terminal losses to the mutual benefit of all interests.

* * *

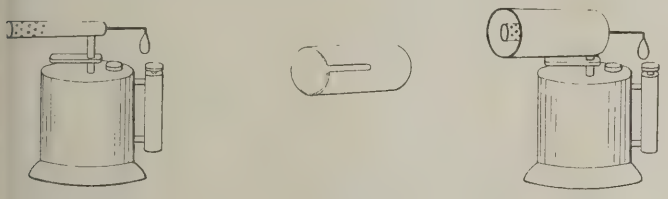
Photo from International Film Service

Train Passing Through the Jungfrau Tunnel, Switzerland

PRACTICAL STUNTS

A Superheater for a Gasoline Torch

On cold and windy days in the winter and very frequently in the spring and fall in exposed places it is rather a difficult matter to make a gasoline torch heat up properly. A great deal of time may be wasted in trying to keep the torch up to a working temperature. One scheme that has been found to work out very well in maintaining the right heating temperature is shown in the illustration. It consists simply of an ordinary tin can with a slot cut in the side as shown. To apply this can to the torch it is necessary to unscrew the gasoline needle valve from the back, slip the can over the burner, the gasoline feed pipe fitting into the slot cut in the can. The needle valve is then screwed back into place through a hole in the bottom of the can. Although the arrangement is not particularly handsome in appearance it serves very well to keep the heat about the burner and in a remarkably short time the latter becomes hot and the torch is in readiness for use.



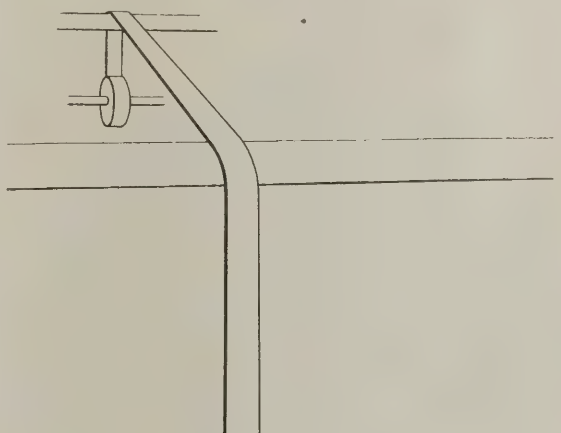
Gasoline Torch Showing the Application of a Simple Superheater

A Novel Way of Fishing a Difficult Run of Conduit

Although the usual manner of fishing a line of conduit is by means of a wire "snake" it not infrequently happens that after all the conduit in a building has been enclosed with masonry that some of the conduit runs present difficult problems when it comes to getting the fish wires through them. It is sometimes possible by using two separate snakes, putting a small hook in the end of each and pushing them into the conduit, one from either end, to engage the hooks at some point in the conduit and then draw out one or the other of the snakes. This, however, is not always as easy as it seems and the following method has been found entirely successful wherever conditions are such that it can be applied. The chief requirement is some sort of compressed air. The method, itself, is exceedingly simple. A small piece of cotton waste is rolled up into a ball so that it fits loosely into the end of the conduit. To this ball of waste a piece of ordinary string is tied, the length of the string, however, must be equal to the length of the conduit. By inserting the ball of cotton waste into the end of the conduit and applying a hose connected to some source of compressed air to the opening, the ball will be blown through the conduit with great rapidity. Precaution should be taken, of course, to have plenty of slack in the string so that it may be fed in as fast as the ball of waste is blown along the conduit. Once having secured a continuous string through the conduit this string may be used to draw in a heavier cord, and this in turn to draw in the wire.

Taking the Stretch Out of Car Lighting Belting

There is a certain amount of stretch in all car lighting belting which if not removed prior to the application of the belt to the car, will cause the belt to become slack so that it may slip off at the pulleys and be lost on the road. In order to overcome this stretching it would seem desirable that some method be designed to take the stretch out of the belt before it is put into service. One road makes use of the scheme shown in the illustration. As the belting is unwrapped from the reel it is suspended from the ceiling and a heavy weight is attached to the lower end. In this way the section of belt between the point of suspension on the ceiling and the weight is under considerable tension and practically all of the stretch has been removed from it when it is put in service. As each successive belt is cut from the reel the weight is attached to the new end.



Sketch Illustrating the Principle of Stretching the Belt

NEW DEVICES

Oil-Immersed Switch Operated by Clapper Type Magnet

Magnetically operated main line switches on alternating current light and power circuits are at times slow and unreliable in closing when a solenoid and plunger must be depended upon for their operation. If the plunger is slightly out of adjustment, its movement becomes jerky and noisy, its sealing pull is diminished, and it does not seat properly.

The Cutler-Hammer Mfg. Co. of Milwaukee, Wis., has developed a new oil-immersed magnetic contactor, operated by a clapper type magnet, which makes possible a more rigid mechanical structure and greater reliability in operation than is obtained in contactors of the solenoid and plunger type. This contactor has a capacity of 100 amperes at 2200 volts, and is particularly desirable as a main line switch for an automatic 2200-volt motor starter, or for the remote control of any 2200-volt light or power circuit. It is built with three poles, unless used with an auto-transformer starter, when five poles are provided.

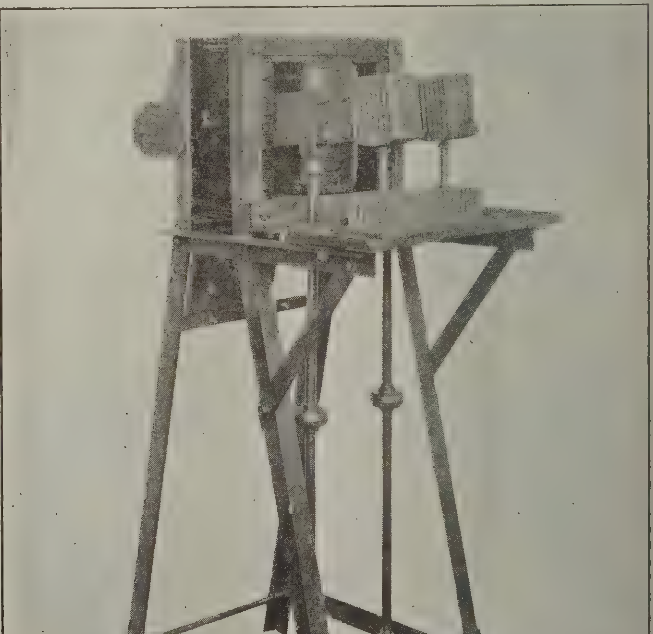
The frame of the contactor, which is of heavy sheet iron, is arranged for wall or switchboard mounting, and carries two cast iron supports with two insulated shafts carrying the contacts. Copper leaf brush contacts are saved from all wear due to breaking the circuit because auxiliary arcing contacts are provided for this purpose. Leads from the contacts connect with suitable terminals extending through high tension insulators mounted on the top of the frame. The armature is firmly pivoted to the frame, and is connected by a rod to an arm of the shaft carrying the moving contacts. The attraction of the armature against the face of the magnet rotates the shaft and closes the switch, which is normally held open by the weight of the moving parts.

A good head of oil is maintained over the contacts by providing a sheet metal tank of ample capacity, and as the contacts are situated above the operating shaft, they are away from any sediment which might accumulate in the bottom of the tank. The arc is broken at the contacts in a horizontal direction and therefore rises to the point of rupture without burning the other parts. Transite shields prevent arcing across adjacent poles.

This new oil-immersed switch may be arranged to have two contactors act as a reversing switch, in which case they are mounted side by side, so when one switch is closed the nose on the armature interferes with the movement of the armature of the other contactor, thereby preventing the closing of the other switch, which would short-circuit the line.

An Electric Rivet Heater

An electric rivet heater which has proved more efficient and economical than the old methods of heating rivets by means of the coke forges and oil burning furnaces, has been placed on the market by the General Electric Company. Saving of material and time as well as improving the sanitary conditions for the worker are the outstanding features for this new device.



Electric Rivet Heater

In operation the rivets are placed between the two electrodes, completing the circuit. They immediately begin to heat, just the same as coils in an electric toaster. The electrode holding the rivets can be operated separately by the use of foot pedals, thus the man operating the machine can take out a heated rivet from one side, replace it with another to be heated, and then alternate to the other side for the next heated rivet. A switch on the back of the machine permits variations of the current needed in heating rivets in different sizes.

This outfit is capable of heating 800 rivets per hour, which is believed to be the maximum number an operator can handle. It is said that this number can be increased, but at present there is no demand for quicker heating.

Some of the outstanding advantages which are claimed for this electric device are: No wasted time in production; no waiting for forge or oil burners to get hot since the first rivet is heated in a few seconds after throwing the switch; rivets are heated from the inside, giving uniformity of heat and this even quality of heat produces a minimum of scale on the rivets; wastage of rivets is reduced to a minimum, since the danger of them burning up as they occasionally do in the forge and furnace, is practically eliminated; the power is used only when the rivets are being heated—a big expense saver; the heater is air cooled and portable, wheels being mounted on the base when desired; the heater is clean and cool and there is no smoke, ashes or contaminating gases, and a minimum of heat regulation.

When necessary to use rivet heaters in small quarters, such as the bulkhead of ships, the heat and contaminating gases arising from gas and coke heaters become so great that the workers have to make frequent trips to the outdoor air. The electric rivet heater eliminates this and consequently adds to the production.

A New Line of Small Meters

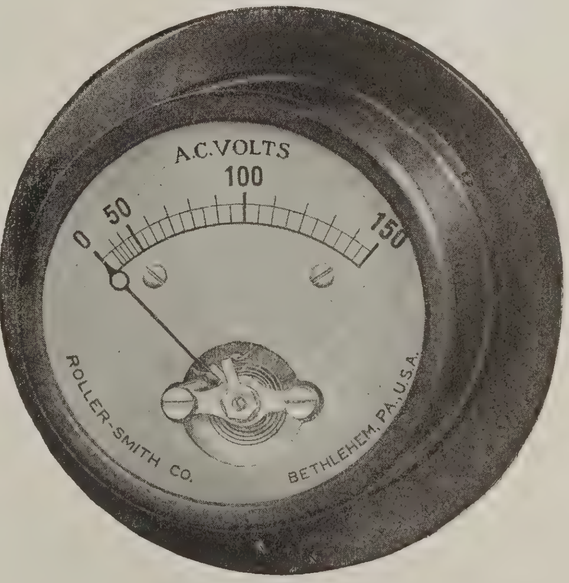
On account of the heretofore relatively small demand for small size, round pattern, switchboard type, a. c. instruments, the principal instrument manufacturers have confined their lines to the conventional 7½-in. and 9-in. diameter sizes. Realizing the growing need for smaller a. c. instruments, the Roller-Smith Company, New York, has recently developed two sizes of these instruments, which are exactly like the corresponding d. c. devices of its Junior and 4-in. Imp types as regards dimensions and general appearance. These new a. c. instruments are particularly desirable in connection with battery charging outfits, current rectifiers, fire and signal systems, laboratories, motor-generator sets, small switchboards and wireless sets or other similar applications.

These small a. c. instruments have exactly the same type of movement used in the larger and more expensive switchboard model a. c. devices and, in fact, are minimum counterparts of the latter. In addition a line of 4-in Imp type a. c. single-phase and d. c. wattmeters, which match in appearance with the corresponding 4-in. Imp type voltmeters and ammeters, are also obtainable. The faces of the wattmeters are necessarily, however, somewhat deeper than those of the ammeters and voltmeters.

The mechanism of the ammeters and voltmeters is of the electro-magnet type and that of the wattmeter is of the electrodynamometer type. A very efficient air damping scheme is used. The construction of the meters is simple and rugged, the whole structure being mounted on a metal plate, thus providing against mis-alignment parts.

The jewels used are first quality sapphires and pivots are of high polished hardened steel. The face is of heavy brass in one piece with black rubberoid finish. Glass fronts are cemented in place. The base is also in one piece and is heavy and rigid. Dials are of bristol board, pure white, with permanent letters and figures. The entire instrument is so constructed as to be dust and moisture proof.

4-inch Imp A. C. Single Phase and D. C. Wattmeter



Junior Imp A. C. Voltmeter, Base Flange Model

All of the instruments are self-contained except the 250 and 300-volt, 4-in., Imp wattmeters and voltmeters and the 80 and 150-volt Junior Imp voltmeters which have external resistances.

General News Section

The Handy Supply & Manufacturing Company, 11737 Detroit Avenue, Cleveland, Ohio, has changed its name to **The Martindale Electric Company,** and in addition to their own well-established lines of electrical specialties, they will act as manufacturers' agents and electrical jobbers.

The Ohio Brass Company, Mansfield, Ohio, announces the acceptance of a position with the company by **W. J. Stanton.** Mr. Stanton has been identified with the electrical industry for the last twenty years, having started with the General Electric Company and remaining there for a period of eighteen years in the testing, engineering and sales departments.

The Railway Association of Canada has announced an embargo on the sending of Canadian freight cars into the United States. Because of the shortage of cars in the United States American railroads are not returning a sufficient number of Canadian cars, according to the Association, and the embargo is considered necessary in order to relieve the lumber famine in Canada.

The Roller-Smith Company, New York, manufacturers of electrical instruments announces the following appointments. **Walter W. Gaskill,** 141 Milk St., Boston, Mass., will act as its agent for Boston and vicinity and other parts of the New England territory. **G. Lindstrom** will occupy the position of works manager at the Bethlehem, (Pa.) plant of the company, and **E. H. Bell** will act as California representative with offices in the Title Insurance building, Los Angeles.

The Farmers' National Council, which claims to represent 750,000 farmers in 18 states, recently adopted resolutions urging a two-year extension of government control of the railroads and endorsing the enactment by Congress of a law embodying the principles of the Plumb Plan. These resolutions were adopted in support of the general principles proclaimed by the National Farmer-Labor Co-operative Conference held at Chicago from February 12 to 14.

The Threatened Strike of the 300,000 members of the United Brotherhood of Maintenance of Way Employees and Railway Shop Laborers, has not been cancelled but has been merely postponed, according to a recent announcement of Allen C. Barker, president of the brotherhood. The announcement was accompanied by statements intimating that the strike will be called if relief is not granted speedily to the members of the brotherhood in the form of wage advances.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis., is devoting new floor space to its Industrial Electric Heating department. The manufacturing of household electric appliances has been discontinued and the additional floor space has been added to that formerly used for this purpose. The industrial heating line is being expanded and includes such products as the electric space heater, soldering iron, linotype pot heaters, chocolate warmers for candy factories, circulation water heaters, etc.

The Chicago Fuse Manufacturing Company, Arthur D. Dana, president, has purchased from the Otis Elevator Company the property at the southwest corner of Sixteenth and Laflin Streets, Chicago, consisting of a two story factory building with four story office section, served by the B. & O. C. T. R. R. William W. Merrill, vice-president and treasurer of the company, states that the business has entirely outgrown their present quarters. During its life of thirty-one years, this company has been compelled repeatedly to seek larger quarters, and it is now one of the largest manufacturers of fuses and switch boxes in the country. Additions are also contemplated. It is expected that the company's two present plants will be transferred to the new location and be in operation by May 1.

The Mechanical and Electrical Features of the new Westinghouse electric passenger locomotives for the Chicago, Milwaukee & St. Paul were explained by N. W. Storer, of the Westinghouse Electric & Manufacturing Company, in an illustrated talk given before the Railway Club of Pittsburgh, on February 26. As the slides were thrown on the screen, Mr. Storer told how each part of the locomotive was constructed and the reason for the adoption of that particular feature. The construction of the wheel trucks, the method of supporting the cab, the drawbar connection and the method of drive were points of particular interest to the railway men present. A partial description of the Westinghouse locomotive was given in the *Railway Electrical Engineer* for February. Further details will be given in a later issue together with a similar description of the electric locomotive built for the St. Paul by the General Electric Company.

The Square D Company, Detroit, Mich., announces several additions and changes in the sales and advertising dep't., which became effective February 1st. **E. A. Printz,** formerly district sales manager of the Chicago territory, was made sales manager; **A. MacLachlan** continuing in the capacity of secretary and director of distribution. **D. M. Stone,** formerly district sales manager of the Pittsburgh territory, was made district sales manager of the Detroit territory. **J. A. Jaques,** formerly in charge of the New York territory, was made the district sales manager of the Pittsburgh territory, and **H. W. Spahn,** district sales manager of the Buffalo territory, was placed in charge of New York. **D. H. Colcord,** formerly of the department of publicity of the Westinghouse Air Brake Company of Pittsburgh, was appointed director of research engineering. The annual sales conference of the Square D Company will held at the Hotel Statler, Detroit, February 16, 17 and 18.

The Joint Ticket Offices participated in by the Pennsylvania Railroad number 26, in 23 different cities; and George D. Dixon, vice-president, announces that the company deems it to the advantage both of itself and the public that these offices be continued permanently. The other roads which share these offices hold the same view, at least to the extent that it has been agreed to maintain all of the offices for the present. These offices are in the following cities: Atlantic City, N. J.; Baltimore, Md.; Brooklyn, N. Y.; Buffalo, N. Y.; Chicago, Ill.; Cincinnati, O.; Dayton, O.; Grand Rapids, Mich.; Indianapolis, Ind.; New York City, N. Y.; Newark, N. J.; Norfolk, Va.; Philadelphia, Pa.; Peoria, Ill.; Old Point Comfort, Va.; Pittsburgh, Pa.; Reading, Pa.; Rochester, N. Y.; St. Louis, Mo.; Toledo, O.; Washington, D. C.; Williamsport, Pa.; Wilmington, Del. It is the intention to rearrange the offices so that each road will have its own separate employes, at a designated part of the counter, so that there may be no misunderstandang as to responsibility for efficient service.

Electrification on the Midi of France

The Midi railway of France, is making preparations to electrify certain portions of its lines, obtaining power from the northern slopes of the Pyrenees. The 3,000-volt d. c. system will be used.

It is reported that the Midi railway will build all its electric locomotive equipment in its own shops and will make every endeavor to contract for all work involved in its electrification program with French concerns. It is expected that ultimately the entire line will be electrified.

A Wooden Railroad

The United States has a railroad, 15 miles long, laid with wooden rails. It is in Alaska and extends from the head of navigation on the Tolovana river up to some gold mines. The owner of the railroad, O. P. Gaustad, of Fairbanks, tells a reporter that his single locomotive, which is an automobile, made by Dodge Brothers in 1916, has done very profitable work throughout the last two seasons. The principle traffic of this railroad consists of logs which are carried from the river up to a sawmill half-way to the upper terminus of the line, and lumber from the sawmill to the mines. The automobile has flanged wheels and hauls three cars at a time. Under favorable circumstances this motor hauls six tons of lading. For ordinary supplies from the river to the mines the freight rate is $3 per 100 lb. During the past season the motor traveled six thousand miles, sometimes making eight trips a day.

Commercial Wireless Spans Two Oceans

Wireless telegraphic communication for commercial purposes direct from the United States across the Atlantic and Pacific Oceans was begun for the first time on March 1. The big transoceanic wireless stations were turned over by the government to the Radio Corporation of America at midnight of February 29. A minute later the first commercial message ever sent direct from the United States to England was started from the New Brunswick, N. J., station. It was received by the Marconi station at Carnarvon, Wales.

On the Pacific coast the high power stations at Marshall and Bolinas, California, began communication with the Hawaiian Islands and with the Imperial Japanese government's station at Fumabashi, Japan.

Electrification on Orleans Railroad

The Orleans Railway of France, says the *Times* (London) Trade Supplement, is contemplating the electrification of about one-third of its entire system, and a concession for the necessary water power has been applied for. Twenty years will possibly be necessary for the completion of the project.

Report on Electrification of Jamaican Railway

The London *Times* Trade Supplement is authority for the statement that an exhaustive report has been received by the Government of Jamaica from an expert of the Westinghouse Electrical International Company on the proposal to electrify the railways, and to provide current for other industrial purposes. The estimated cost of electrifying the railway, including the required power station, equipment and transmission lines to supply other proposed plants and industries, is as follows:

Power Plants	$849,320
Sub-stations	333,320
Motive power—electric locomotives and motorcars—net (cost of new less sale of old motive power)	357,650
Total	$3,393,590

The saving in the cost of operation would be approximately $265,600 a year, which is 7.82 per cent of the cost of electrification.

A. I. E. E. Holds Electric Traction Meeting

The 358th meeting of the American Institute of Electrical Engineers was held in Pittsburgh on Friday, March 12, under the auspices of the Pittsburgh Section and the Traction and Transportation Committee. All of the meetings and the dinner were held at the William Penn Hotel.

The morning was devoted to an inspection trip through the East Pittsburgh plant of the Westinghouse Electric & Manufacturing Company, where the visitors were given an opportunity to inspect the electric passenger locomotives which this company is now building for the Chicago, Milwaukee & St. Paul. Immediately after the inspection the visitors were given a luncheon in the new lunch club of the Westinghouse company.

The afternoon session began at 2:30 o'clock in the ballroom of the William Penn Hotel. The following papers were presented:

1. Short Circuit Protection for Direct-Current Substations—J. J. Linebaugh.
2. Flashing of 60-Cycle Synchronous Converters and Some Suggested Remedies—Marvin W. Smith.
3. Automatic Railway Sub-stations — Frank W. Peters.
4. Automatic Sub-stations for Heavy City Service—R. J. Wensley.

The authors of papers numbers 1 and 3 are from the General Electric Company, and the authors of numbers 2 and 4 are from the Westinghouse Electric Company.

A subscription dinner was held at 6.30 o'clock at which the members and delegates were welcomed by H. D. Shute, vice-president of the Westinghouse Electric & Manufacturing Company, and some prominent officials of one of the operating companies in the Pittsburgh district.

At the evening meeting the design of the new type of electric locomotive now being furnished the Chicago, Milwaukee & St. Paul was presented by representatives of both of the large electric companies, N. W. Storer presenting the Westinghouse design, and O. W. Batchelder presenting the General Electric design.

Calvert Townley, president of the institute, presided at the meetings.

Material Handling Machinery Manufacturers' Association

The annual meeting and convention of the Material Handling Machinery Manufacturers' Association was held in the Waldorf-Astoria, New York, February 26 and 27, 1920. The program provided for a business session on the morning of the first day, followed by a luncheon and the presentation and discussion of papers in the afternoon. On Friday morning the advertising managers of the manufacturers of mechanical handling machinery held an advertising council assembly at which A. J. Barnes of the Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., presented data covering a recent survey of the field made to ascertain the potential and actual demand for industrial units in the industrial field for industrial trucks, tractors, lift trucks, industrial locomotives, portable conveyors and detached electric hoists.

Another paper by E. R. Davis, advertising manager, General Electric Company, Schenectady, N. Y., outlined the need for an encyclopedia correlating material handling machinery, and the information was disclosed that arrangements had been made by the Simmons-Boardman Publishing Company, New York, to produce such a volume to cover the field of cranes, conveyors, elevators, escalators, stacking machines, industrial trucks, motor trucks, transfer tables, turntables, industrial locomotives, and combinations of these units as well as steam, electric and gasoline power units as applied to the industry.

The afternoon session on Friday was devoted to the presentation and discussion of papers of general interest to the industry. A paper of special interest to railroad men was presented by B. E. Fitch, president of the Motor Terminals Company of New York and Cleveland. It discussed the application at Cincinnati, O., of electric overhead traveling cranes and electrically operated hoists in combination with demountable truck bodies or containers, used with motor trucks for handling interline l. c. l. freight interchange between all the railroads of that city and sub-stations of each road. An abstract of Mr. Fitch's paper is published elsewhere in this issue.

Following is the list of the board of governors elected for the year 1920-21. (At a meeting during March this board will formally elect a president, vice-president and treasurer, and secretary to serve for the coming year): F. W. Hall, Sprague Electric Works, New York; H. W. Standart, Northern Engineering Works, Detroit, Mich.; J. C. Walter, Alvey Ferguson Company, New York; W. F. Merrill, The Lamson Company, Boston, Mass.; R. W. Scott, Otis Elevator Company, New York; D. V. Jenkins, Watson Elevator Company, New York; L. C. Brown, Elwell Parker Electric Company, New York; R. Owens, Lakewood Engineering Company, Cleveland, Ohio; F. Stadelman, Wellman, Seaver, Morgan Company, New York; T. Robins, Robins Conveying Belt Company, New York; G. O. Helmstaedter, Hyatt Roller Bearing Company, New York, and G. W. Miller, Jeffrey Manufacturing Company, Columbus, Ohio.

TRADE PUBLICATIONS

The National Lamp Works of the General Electric Company at Nela Park, Cleveland, Ohio, is distributing a 16-page pamphlet entitled a "Survey of Lighting Conditions in Industrial Plants." The pamphlet contains information gained from a personal survey by trained investigators in several hundred industrial plants.

The National X-Ray Reflector Co., New York, is distributing its 80-page illustrated catalogue "F" in which is completely listed all of the various lighting equipment manufactured by the company. The book is divided into six sections, as follows: Luminous Fixtures, Metal Fixtures, Compone Fixtures, Curtis Lamps, Pedestal Lighting and Bank Desk Lighting.

The Borden Company, Warren, Ohio, has recently issued its catalogue No. 12 containing 32 pages. The booklet is 6 in. by 9 in. in size and contains many illustrations of the pipe threading equipment which this company markets under the trade name of "Beaver." The catalogue contains a complete list of prices and is accompanied with a discount sheet.

Constitution of the United States.—The Clark Equipment Company, Buchanan, Mich., has published an attractive booklet containing a reproduction of the Constitution of the United States and all amendments. It is illustrated with pen portraits of notable American Presidents, by W. M. Young. This is a booklet which every American would be glad to have and will be mailed on request.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis., has recently distributed an illustrated booklet which contains a reprint of an abstract given by Peter P. Dean, at a meeting of the American Society of Mechanical Engineers. The booklet is devoted to a description of the Dean control system of electrical operation for gate valves. The desirability of having remotely controlled valves in power stations, water works, dry docks, etc., is pointed out.

"Insuring Full Returns on Truck Investments" is the title of a new 8½ in. by 11 in. four-page descriptive leaflet known as Publication 806, printed by the Cutler-Hammer Manufacturing Company of Milwaukee and New York. The leaflet describes and illustrates the new C-H automatic sectional-type battery charging equipment for charging battery driven vehicles, trucks and locomotives. A separate section is shown in detail and an illustration of a six-section equipment indicates the method of arranging in complete panels. How this charging equipment automatically cares for the charge, tapers the rate and terminates the charge, are discussed at some length.

Railway Electrical Engineer

Volume 11 April, 1920 Number 4

THE LAW OF SUPPLY AND DEMAND

Value depends almost entirely upon two things—supply and demand. The fundamental economic law of supply and demand is as old as mankind itself. There have been so many conflicting opinions voiced regarding the reason for the unstable, topsy-turvy, financial conditions of today that it is no small wonder the whole subject, pertinent as it is to every one, has been enveloped in a cloud of mystery. Thinking men who have sought for the causes underlying the present unhealthy financial conditions, have arrived substantially at the same conclusions—namely, that the old law of supply and demand is in full swing and that right now the demand is far ahead of the supply. There is no doubt but that there are other contributory factors, among which might be mentioned the inflation of credit and currency, governmental and private extravagance, and faulty taxation, but among those who have given the matter much thought it seems to be the concensus of opinion that the chief difficulty lies in our inability to make the proper adjustment between supply and demand.

Perhaps no better example can be cited than that portraying the conditions which followed our own Civil War. The high cost of living at that time was occasioned by nothing more or less than the failure to adjust the supply to meet the demand. If the law of supply and demand has controlled the wages of workmen in the past, and through them the cost and therefore the price of commodities, it is a reasonable basis upon which to forecast what might be expected under similar conditions.

A consideration of the events which transpired during the first few months of the Great War clearly reveal the working out of the law of supply and demand. The production of war material was stimulated at the expense of everything else. Large numbers of workers were withdrawn from productive occupations. What could be more reasonable to expect than an advance in prices. Now, that the war is over and the demand for war material has ceased, the men have returned to peace-time occupations, but the high prices still remain. Why? If the reasoning is correct, there is but one answer, and that is that sufficient time has not yet elapsed for production to catch up with the demand.

It might be thought that we are long in catching up with the demand, but it must be remembered that during the war the supply for our industrial needs fell very far behind. The United States must also supply the immediate needs of the European countries, with the result that this additional burden still further postpones our return to a normal condition. But it is not reasonable to suppose that this condition is going to continue indefinitely. None appreciate more keenly than these debtor countries their economic positions, and by their diligence, energy and thrift, before long they will again be able not only to supply their own requirements, but will become formidable factors in the competitive markets of the world. The time will then have arrived when the supply has caught up to the demand. In fact, it is more than likely that the supply will be in excess of the demand and some nations will be without a market.

This, then, is what we can look forward to with a fair measure of assurance. Just what it will mean to the people of the United States will depend very largely on how they fortify themselves during the present period of prosperity. To those who have the foresight to practice thrift and economy, the readjustment will come without serious disturbance, but if the majority continue along in their present extravagance, working less and less, there is nothing that can prevent a disastrous period of depression, with its accompanying unemployment and suffering.

Prices will come down—there is no question about that. Whether the drop will be sudden, with hard times and panic, or whether the decline will be gradual, will depend altogether on the possibility of arousing the people of the nation from their existence in a "fool's paradise" and making them recognize the necessity for industrial preparedness.

WORKING HOURS

Since the eight-hour day has been in effect in railway service certain disadvantages, which are distinctly the result of the shorter working day have forced themselves into prominence. It is not a disadvantage arising from the curtailment of the working day, for the point may well be taken that if a man actually works, an eight-hour day is long enough. The trouble comes from the fact that on some roads the eight-hour shift begins at a particularly unfortunate hour. In the majority of cases the day shift begins work at seven o'clock. In such departments as require continuous service this means that the men are through work at three o'clock. Too frequently it happens that the time in the late afternoon could be much more profitably utilized than could, perhaps, the hour between seven and eight in the morning. In terminals, where men are employed in various departments, it is not altogether wise for all of these men to commence work at the same time. This condition is particularly true in the car lighting department, and there is no doubt but that there are many cases where it would prove to be a distinct advantage if the day shift, instead of starting at seven o'clock, began work one hour later in the morning.

THE EVIL OF OVERTIME

There is no question but that there are occasions when it is imperative that work be continued beyond the normal eight-hour working day. The number of these occasions, however, is relatively small and the practice of allowing work to be completed at overtime rates is something which should be discouraged. If the overtime rate is frequently allowed it will eventually partake of the nature of a premium on laziness, for where the punitive overtime rate has been the rule there is an undeniable tendency on the part of certain workmen to slow up the work so that they may receive a higher wage by continuing their day beyond the eight-hour period. On the other hand, where the overtime rate has been practically discontinued, it has been found that results secured are substantially the same as those of the eight-hour day plus the overtime. In these days of costly materials and high wages, the elimination of overtime is a thing which no railroad can afford to disregard.

THE ST. PAUL ELECTRIFICATION

The operation of the two electrified sections of the Chicago, Milwaukee & St. Paul should soon offer a solution to two problems confronting all roads which are now using or contemplating the use of electric motive power.

The two new types of electric passenger locomotives now in use on the St. Paul are almost totally unlike each other and neither one bears much resemblance to the original locomotives which have been in service on the eastern electrified section for the past five years. Evidently the designers decided that something more suitable than the original locomotives could be designed for passenger service and accordingly brought out the two new types. Operation during the coming year should suffice to show which one of the two types is best suited to the heavy passenger service for which they were designed.

Some extremely valuable information pertaining to costs may be obtained from the operation of the western electrified section. This section, which extends from Othello, Wash., 207 miles to the coast, was put into operation on March 5, 1920. Accurate cost data is of first importance in the consideration of an electric traction problem, and such data has been conspicuously lacking in the solution of almost all previous electrification projects. To be sure it was necessary for the pioneers who had no precedent to get along without it, but little accurate data is available even today after trunk line electrification has been in regular operation for 25 years. This is largely due to the fact that most of the electric systems are superimposed upon steam systems. Under this condition it is necessary to maintain roundhouses, water tanks, coal docks, turntables, etc., which are not needed by electric motors. Furthermore, both steam and electric trains are operated over the same tracks, and it is practically impossible to segregate the operating costs of the two.

Fortunately, steam operating costs have been kept in very complete detail on the now electrified western division of the St. Paul. Complete electric operation has been put into effect, and another year should bring out some facts on electric operation which many roads have been patiently waiting for.

RAILROADS IMPROVE CAR LIGHTING

In the development of lighting cars by electricity it is not surprising that the railroads themselves, in many instances, have been the instigators of improvements. Railroad men have had the advantage of living close to the equipment with ample opportunities for studying it under all sorts of operating conditions. The article which appears on page 123 of this issue points out at least one way in which car lighting apparatus has been made to extend its scope of usefulness. Axle generators designed for mainline operation have usually failed to meet the requirements of the slower speed branch line service, in many instances failing to charge the battery adequately and in extreme cases not cutting in at all. Any modification that is reasonably simple whereby standard mainline equipment can be made to operate satisfactorily in branch line service, is, therefore, of interest. Mr. Wanamaker and Mr. Pennington have shown to what extent they have been able to secure this result on the Rock Island Lines, but we feel certain that there are other engineers on other roads who have also made important improvements in car lighting equipment. What have you done to help along the work? Let us publish your ideas for better service.

NEW BOOKS

Armature Winding and Motor Repair. By Daniel H. Braymer, A. B., E. E., Managing Editor of "Electrical World;" 515 pages. Published by McGraw-Hill Book Company, Inc., 239 West 39th street, New York.

The treatment of the subject discussed in this book is clear, easily understood, and in every instance is written from the practical man's viewpoint. Although written to meet the requirements of men engaged in repair shop work, power station work, and in the maintenance of motors in industrial plants, the book also makes a strong appeal to students of electricity. The material presented was obtained from actual experiences and the pages are full of practical remedies that have been applied by repairmen in the solving of puzzling problems; the information imparted will be of decided assistance to men who are in need of such practical help. The book is comprehensive in the treatment of the subject, and there are few, if any, armature winding and motor repair problems, the solution of which cannot be found in its pages. It is well illustrated with many diagrams and photographs, showing in great detail the various steps in armature winding and motor repair. Mathematical calculations have been omitted to a very great extent, so that the information presented in the book may be available to those who have but a limited knowledge of mathematics.

An appendix, consisting of 35 pages, contains practically all of the data and reference tables that are required by the armature winder or motor repairman.

St. Paul Passenger Train on the Western Electrified Section

The St. Paul Electric Passenger Locomotives*

Some of the Details of Design Are Described by Representatives of the Manufacturing Companies

THE two new types of electric passenger locomotives built for the Chicago, Milwaukee & St. Paul were designed for the same class of service by different groups of engineers working independently; from an inspection of the finished locomotives it would appear that the general design of the two types could hardly be more different.

Roughly the requirements for both designs were as follows: The locomotives must collect 3,000 volt direct current power from an overhead catenary. They must be able to haul a 12-car passenger train weighing 950 tons over a two per cent grade, compensated for a distance of 20 miles, and over a 2.2 per cent grade compensated for a distance of 17.8 miles. They must maintain speeds of approximately 25 miles an hour up two per cent grades, 35 miles an hour up one per cent grades, 60 miles an hour on level tangent track and must hold trains on down grades by regenerative braking at speeds consistent with safe operation. The sharpest curve on the main line is 10 deg., but the locomotives must negotiate a 16-deg. curve in the yards satisfactorily. The locomotives must also supply current for lighting the trains and charging the train storage batteries at a voltage of from 60 to 85 and must be equipped with an oil-fired boiler, to be supplied by the railway company, to furnish steam for heating the train.

General descriptions of the two locomotives were published in the *Railway Electrical Engineer* of December, 1919 (page 449), and February, 1920 (page 45).

The General Electric Locomotive

By A. F. Batchelder and S. T. Dodd

The running gear of the General Electric locomotive is composed of four individual trucks, two end trucks having three axles each, and two center trucks having four axles each. These trucks are connected together by special articulation joints. The motor armatures are mounted on the axles and the motor fields are carried on the truck frames.

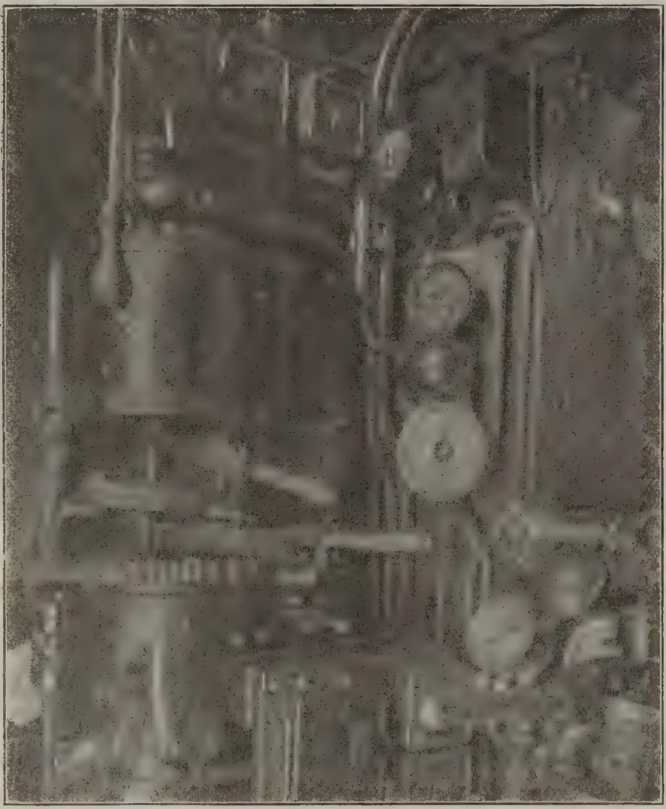
The superstructure is made in two sections of similar design with a third section between them. The third or central section contains the train heating equipment, which consists of an oil fired steam generator, together with water and oil tanks. This unit is complete in itself, and is carried over supports attached to the two middle trucks. It can be readily removed for repairs without interfering with any other part of the locomotive. It is placed between the two operating cabs in order to be easy of access to the engineer's helper or fireman, from either location.

The two end sections are similar to each other in appearance. The operator's cab in either section is on the inner end next to the heater cab above described, in order that the operator can be convenient to the heater and in order to allow a maximum space for apparatus in the apparatus cab or outer end section. Another advantage of this arrangement of cabs is that the operator can have access to any section of the locomotive requiring his presence without passing through a section containing high-tension apparatus. The engineer's or operating cab contains a main or master controller, the air brake valves and handles, and an instrument panel, containing air gages, ammeters, and speed indicator. The engineer uses either of the two operating cabs according to the direction in which he is running.

---

*Abstracts of papers presented before the 358th meeting of the American Institute of Electrical Engineers at Pittsburgh, Pa., March 12, 1920.

A door gives access from the operating cab to the apparatus section, which extends with a cylindrical top to the extreme end of the locomotive. The cylindrical construction naturally adapts itself to the protection of the apparatus included and in addition to this it has the advantage of allowing a clear vision for the operator from his normal operating position. Contained in this apparatus section are the resistors and contactors to control the power circuits of the locomotive. The starting resistors are placed in two rows on each side of the central passage just above the floor of the superstructure and are covered at the sides by removable covers which when opened will allow the separate resistor boxes to be slid out upon the longitudinal running board outside of the apparatus cab. The air compressor for the air brakes, the motor-generator set for train lighting, and the storage battery for marker lights and emergency control, stand upon the same level as the resistors, and can be removed or replaced in a similar manner. Above the resistors are located the contactors with their arc chutes facing a central aisle two feet wide. This allows ample arching space and room for inspection of contactors. Above the contactors is the cylindrical roof of the locomotive with trap doors for removing the contactors in case replacement is necessary.



Control Apparatus in Engineer's Cab of the General Electric Locomotive

Motors

The motors are of the bi-polar gearless design which was adopted by the New York Central 14 years ago for operating heavy passenger trains between Grand Central Station and Harmon, N. Y. To insure light weight per axle, flexibility in control, good truck arrangement for curving as well as for high-speed running, twelve motors are chosen, each of relatively small capacity. They are especially designed to withstand high temperature, being insulated with mica and asbestos. The continuous rating of each motor at 1,000 volts and with 120 deg. rise by resistance is 266 hp., corresponding to 3,500 tractive effort at the rim of the drivers at a speed of 28.4 mi. per hr. Forced ventilation is employed for cooling. The armature core is provided with holes for the passage of ventilating air. Ventilating blowers are located above each motor armature and deliver air at the commutator end of the motor where it divides, a part passing through the armature and a part back through and around the field coils, where it escapes upwards and is afterwards used for ventilating the starting resistors.

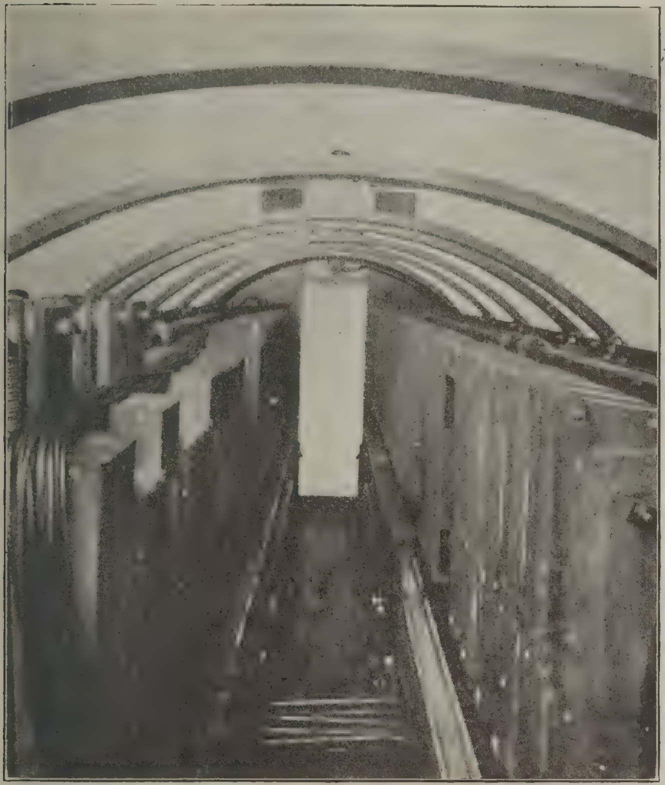
View from Engineer's Position on General Electric Locomotive

This type of motor lends itself nicely to simple and compact locomotive design, as the frame is made use of to furnish the entire path for the magnetic flux. The pole pieces and field coils are fastened to the cross transoms of the trucks and the magnetic flux passes horizontally in series through all twelve motors, finding a return path through the locomotive frame. The articulation joints between the trucks are made in such a manner that large surfaces are in contact to provide an easy path for the flux. The pole pieces are made flat in order to prevent the pole pieces from coming in contact with the armature during the vertical movement of the truck frame on its springs or when removing or assembling the armatures. A minimum clearance of ⅛-in. on each side is allowed between the armature and the pole piece tips. The brushholders are bolted to the transom, allowing the brushes to move up and down with the fields as the frame rides on the truck springs.

Control

In choosing the control apparatus special care has been taken to use individual pieces of apparatus best suited to the particular requirements. Where single independently operating switches are necessary, as on the resistance notches, electro-magnetic control is used. Where several switches are required to operate at one time, as in changing from series to parallel motor connections, banks of switches with electro-pneumatic cam control are used, thus insuring positive operation, eliminating interlocks, and simplifying the wiring.

The control for motoring is arranged for four motor combinations. The first combination has nine rheostatic steps, one full field step, and one tapped field step, with twelve motors in series across 3,000 volts. The second combination has six rheostatic steps, one full field step, and one tapped field step, with six motors in series and two sets in multiple. The third combination has eight rheostatic steps, one full field step, and one tapped field step, with four motors in series, and three sets in multiple. The fourth combination has eight rheostatic steps, one full field step, and one tapped field step, with three motors in series, and four sets in multiple. This results in a total of 39 control steps with a choice of eight operating speeds, exclusive of the resistance steps.



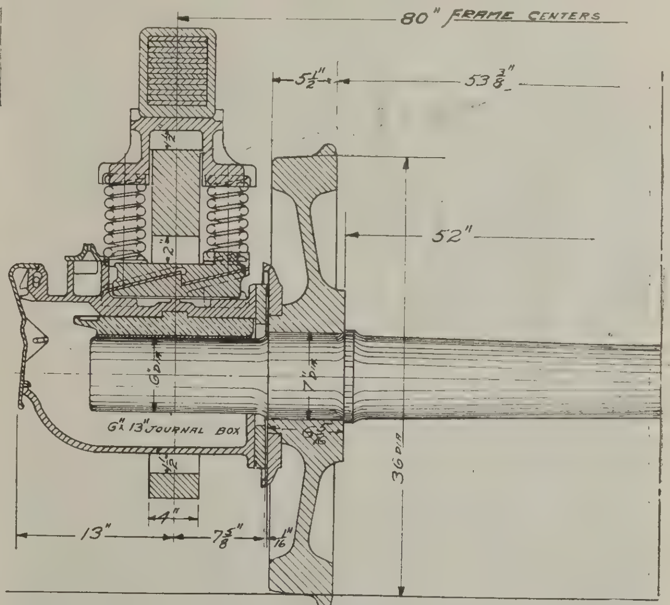
Interior of No. 2 Apparatus Cab of the General Electric Locomotive with Roof Removed

The regeneration of power for braking is accomplished by using some of the motors for exciting the fields of the others, which in turn are used as generators to return power to the line.

As a provision against short circuits, or extreme overloads, a quick acting circuit breaker is provided in the apparatus cab which will protect the circuit in less than 1/100 of a second.

For flexibility in curving, the running gear is made up of four trucks, each of a relatively short wheel base. The two middle trucks have four driving axles each; and the two end trucks, two driving axles and one guiding axle each, making a total of 14 axles. The trucks are connected together with articulated joints which allow of no relative lateral movement between them, so that each truck positively leads the following truck.

To soften any lateral blow that may be given against the rail head, the leading and trailing axles are allowed a movement of one-half inch relative to the truck frame, either way from their central position. This movement takes place against a resistance introduced by wedges above the journal boxes which tend to hold the box in its central position and to give a dead beat action opposing the motion. To further protect the track from lateral displacement on the ties, the outer end of the superstructure is carried on rollers, bearing on inclined planes upon the truck frames, while the inner end of the superstructure is rigidly bolted to one of the middle trucks. This construction tends to hold the leading and trailing trucks in their central position. When a blow is delivered by the leading or trailing truck against the rail head, the superstructure, which is rigidly bolted to the middle truck, is displaced laterally across the outer truck very much as a boiler of a Mallet locomotive swings across its leading truck. In such a sideways displacement, the weight of the superstructure rolls up on the inclined plane on that side, and thus transfers weight to the rail that is affected, thereby increasing the adhesion of the rail to the tie. This action really has two results. It not only increases the holding power between rail and tie at that point, but it introduces a time lag and increases the time and distance during which the pressure is delivered to the rail head.



Cross Section of Journal Box, Showing Wedges Used to Give Resistance to Lateral Movement

The Baldwin-Westinghouse Locomotive

By N. W. Storer.

The locomotive is built in a single unit, having one long cab, carried on running gear of the 4-6-2-2-6-4 type. The running gear consists essentially of two Pacific type running gears, coupled back to back.

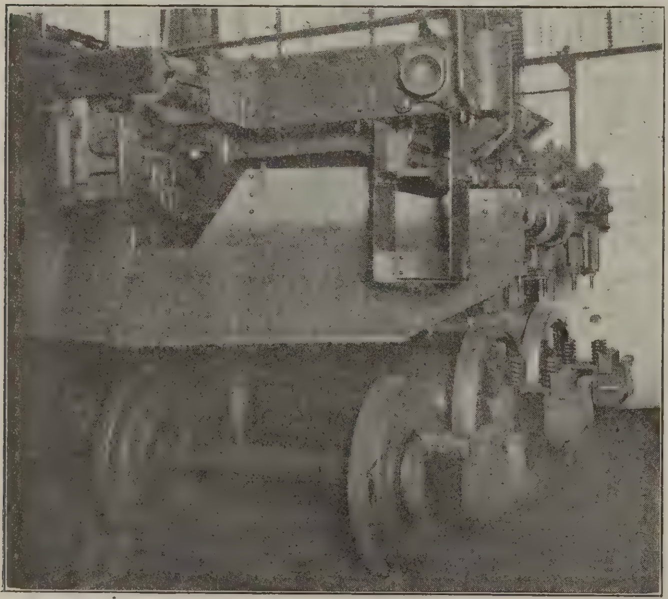
The side frames are steel castings, joined over the four-wheel trucks by a heavy "A" frame casting; also by heavy cross-ties between the drivers which also support the motors, carry the center pin and carry the coupling between the two running gears. Each half running gear has six spring-supported plungers on which the cab rests. There are two supports at each end and two in line with the center pin. By the use of shims, the distribution of weight between the two ends of each running gear may be adjusted as desired.

The equalization is of the standard three-point type; the leading bogie being cross equalized with the leading pair of drivers and the pony axle being equalized with the two adjacent driving axles on the sides. Extra points are provided in the equalizing levers so that practically any distribution of weight that is desired can be attained.

The driving wheels are 68 in. in diameter; the journals 8½ in. by 14½ in., located outside of the wheels. The drawbars, with Miner friction draft gears, are carried in the "A" frame casting, previously mentioned.

The coupling between halves of the running gear consists of a long bar of a box section. The coupling pins are 10 in. in diameter and are located well inside the pony axles. The pins are hollow, filled with oil-soaked waste and have oil holes provided that keep the pins well lubricated.

The four-wheel trucks are of the "Woodard" type with outside journals; 36-in. rolled steel wheels and cast steel side frames. The journals are 6½ in. by 14 in. The two-wheel truck is of the well known "Rushton" side-bearing type, also with the outside journals and 36-in. wheels. The journals are 6½ in. by 14 in. Brake shoes are provided on all drivers. A modified form of the 14-EL Westinghouse Air-Brake Company equipment is used.

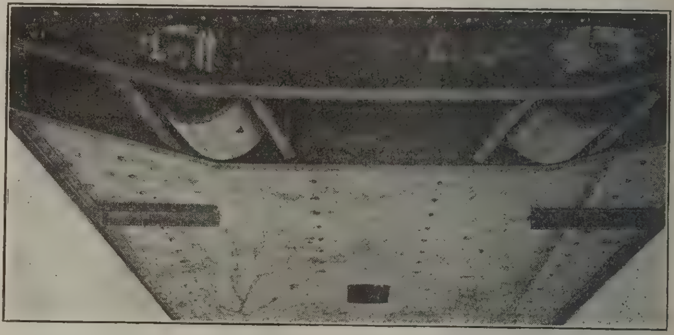

Leading Truck of the General Electric Locomotive Partly Assembled, Showing Wedges in Place on Journal of Guiding Axle

The cab is 78 ft. 0 in. long, 10 ft. 2 in. wide; is strong and rigid so that it can be lifted at the ends. The main strength lies in the two bridge girders extending from end to end. The heavy cross-braces and the side members and top of the raised deck down the middle of the cab, form a construction that is light, but stiff. The cab is divided by cross partitions into compartments, one at each end for the engineer, and the others for the various parts of the cab equipment.

The total motor rating of the locomotive is 4,200 hp. on the one-hour basis. The continuous rating is 3,400 hp.

Driving Motors

The six-driving motors are of the twin armature type. Both armatures are contained in a single frame, arranged to secure the maximum economy of weight. The fields are of the standard four-pole type with four salient poles and four inter-poles for each armature. There are brush arms on each commutator which are easily accessible. Each armature is wound for 750 volts, but the two armatures and the two sets of field windings are connected permanently in series so that the rating of the complete motor is based on 1,500 volts. The motor is designed for field control by inductive shunts.


Platform and Rollers Which Constitute Upper Half of Centering Device on the General Electric Locomotive

Quill Drive

The one hour rating is 700 h. p. The continuous rating is 567 h. p. with forced ventilation and 400 h. p. without blowers. The motors are mounted rigidly on the cross ties of the running gear, one being mounted directly above each driving axle. Each motor is geared to a quill centered in bearings in the motor frame and surrounding the driving axle with a clearance all around when axle and quill are concentric of 1¾ in.

The quill carries the gear and is connected to the drive wheels by long helical springs which are clamped rigidly at the ends in castings which are bolted one to the quill flange and the other to the drive wheel. There are seven springs at each end, worked in compression in one wheel, while those in the other are in tension. All springs with clamps are interchangeable.

They are easily accessible for inspection, and any spring may be removed without disturbing any other part of the running gear.

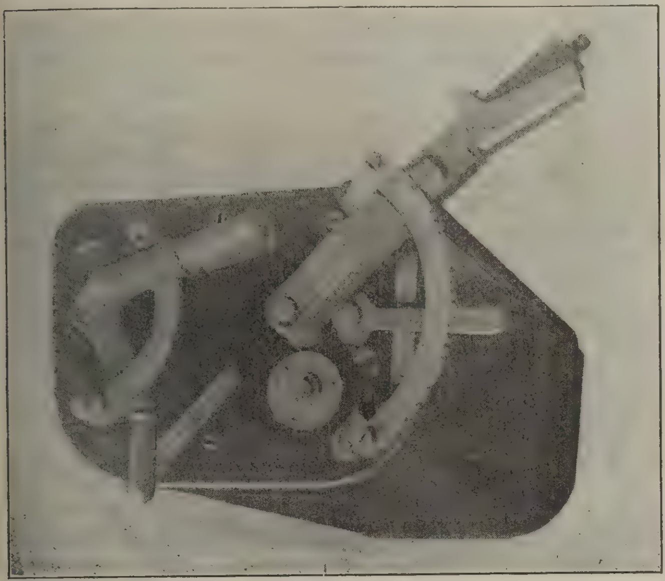
Main Motor Control

The six motors are arranged to be connected in three combinations:

1. All in series, giving one-third speed.
2. Three in series, two in parallel, giving two-thirds speed.
3. Two in series, three in parallel, giving full speed.

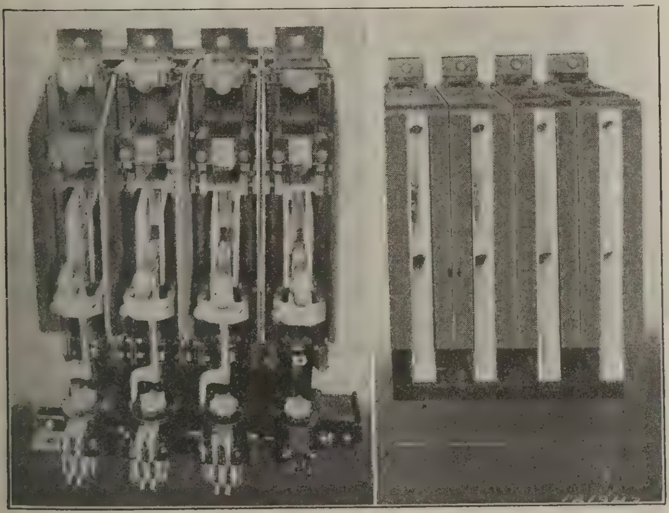
Inductive shunts are applied to the fields on all three of these positions. Shunt transition is used in passing from one combination to the next. When regenerating, the motors are separately excited from the two axle-driven generators which are carried on the inside axles of the two four-wheeled trucks and geared to them like ordinary interurban railway motors. These generators are separately excited and the field strength of the main motors is controlled by varying the fields of the exciters.

The scheme that is used for regeneration includes the useful; making a total of thirty-six resistance steps and with the exciter armature, main motor field circuit, and also with the main motor armature circuit, so that the field excitation is dependent, to a certain extent, on the armature current.


Top View of Westinghouse Master Controller

The master controller has four control drums and four operating handles.

1. The speed drum, which controls the resistance switches and line switches; field shunts during motoring and the exciter voltage during regeneration.


Rear and Front Views of Four High Voltage Unit Switches

2. The reverser drum, which performs the usual function.

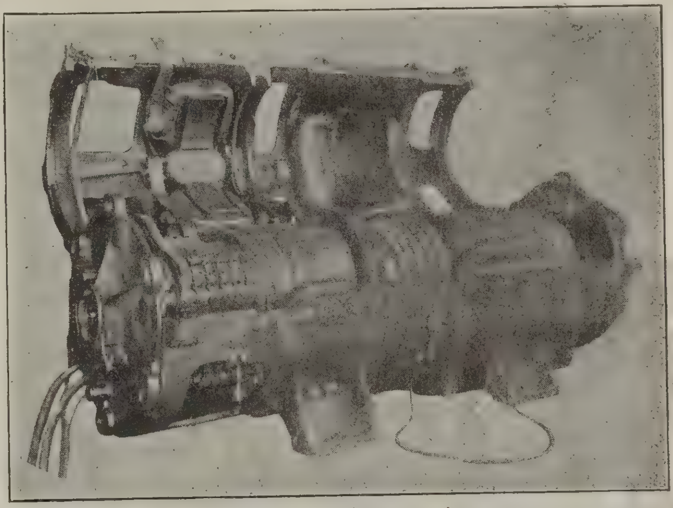
3. The motor combination drum, which has three positions, each corresponding to one of the three motor combinations.

4. The regenerative drum, which changes the connections from motoring to regenerating and vice-versa.

The master controller is arranged so that the controller may be thrown from the "off" position to the second or third speed combination, if desired, without passing through the lower combinations.

The engine-man is prevented from accidentally starting the locomotive from rest, in the second or third combination, by an interlock in the controller which prevents the line switches from closing when the motor combination lever is in the second or third position, unless he pushes a button in the top of the master controller. It is, therefore, necessary when applying current with the locomotive at speed, to press the button when it is desired to go immediately into the second or third combination.

There are thirteen resistance steps, all of which are available in both first and second speed combinations. On the third combination, there are ten steps that are useful; making a total of thirty-six resistance steps and two field shunting notches in each combination, or a total of forty-two steps in the master controller.


Westinghouse 3000-Volt, 85-Volt Motor Generator Set

The main resistance is arranged in three groups, each of which has five switches, each short-circuiting a section of resistance. These three groups are connected all in series for the first combination, and three in parallel for the second and third combinations. The sequence of closing the resistance switches is the same on all combinations. The resistances are always connected in series before the master controller reaches the "off" position. The overload trips are arranged to open the resistance switches and insert the entire resistance in series before the line switches are opened.

Switches

The unit switches are numbered from "1" to "33." Each switch is provided with a very powerful magnetic blowout with arc chutes of arc-resisting material, and an arc splitter. It is electro-pneumatically operated and is designed so that it is very thoroughly protected from insulation troubles and for ease of inspection and overhauling.

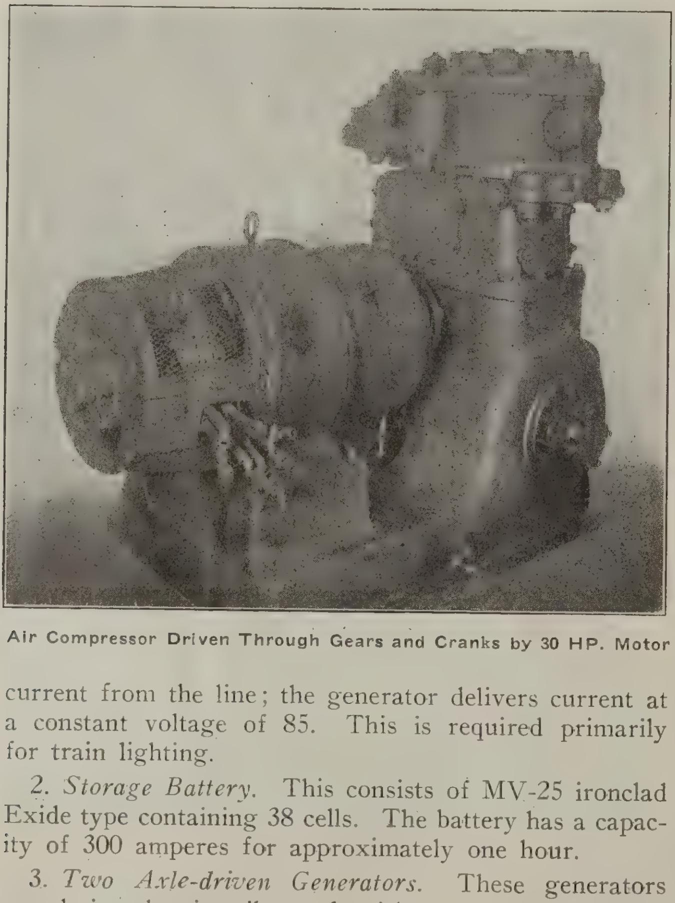
The cam switches are designated by numbers and letters. The number corresponds to the group in which the switch is placed and the letter corresponds to the particular switch in the group.

Those of Nos. 37 and 38, which are the groups operating the field shunts, also Nos. 39 and 40 which control the stabilizing resistance during regeneration, are provided with magnetic blowout; but the switches for the reverser, which never close or open the circuit with current on, have no arc chutes or blow-outs. Groups Nos. 34 and 35, which make the different motor combinations, have barriers placed between adjacent switches which have a large difference in potential, but no magnetic blow-out, since these switches are never used for opening the circuit under load. The groups are operated electro-pneumatically.

Auxiliaries

Power for the auxiliary motors, control circuits, train lighting, motor excitation, etc., is derived from three sources:

1. *Motor-Generator.* The motor of the set receives current from the line; the generator delivers current at a constant voltage of 85. This is required primarily for train lighting.



Air Compressor Driven Through Gears and Cranks by 30 HP. Motor

2. *Storage Battery.* This consists of MV-25 ironclad Exide type containing 38 cells. The battery has a capacity of 300 amperes for approximately one hour.

3. *Two Axle-driven Generators.* These generators are designed primarily to furnish current for exciting the main motors during regeneration.

The storage battery is always available to supply current for locomotive lights, control circuits, and the air-compressor motor for short periods. When the locomotive is in service, the generator of the motor-generator set is always in parallel with the battery, and from this dual source is always taken the power for lighting the locomotive and train, control circuits, cab floor-warmers, small blower motors for inductive field shunts, boiler blower and exciting current for the axle generators. In addition, the current for the air-compressor motor is supplied from this dual service whenever the locomotive is standing still or regenerating.

The axle generators are, as stated, used primarily for exciting the main motors during regeneration. At other times, when the locomotive is in motion, the axle generators are automatically connected to the auxiliary circuits from which the compressor and main blower motors take power. At this time the voltage is automatically maintained at 90.

A two-stage compressor with inter-cooler, having a displacement of 150 cubic feet per minute, is provided. It is a double-acting, upright type, driven by an industrial type motor.

Two blowers are provided to supply forced ventilation to the driving motors. They are driven by motors that are duplicates of the compressor motor.

The axle generator circuits are shifted from one circuit to another by a group of the same type of cam operated switches as are used in the main motor circuits. The field rheostats for the generator of the motor-generator set and the axle generators are operated by small motors. As the fields of the two axle generators are connected in series, only one rheostat is required for them.

The switches for controlling the blower and compressor motors and the high-voltage motor are magnetically operated.

The motor of the motor-generator set is protected from overload or short circuit by a small permanent resistance in series and a set of three expulsion type fuses which blow in series, the first two inserting additional resistance in the circuit, and the last opening only after a relatively high resistance has been inserted and the current consequently limited to a low value.

A Sangamo wattmeter is provided which has separate dials for integrating the motoring watts and regenerating watts. A full set of motor ammeters is provided, and also a volt-meter reading line volts. An ampere-hour meter is provided for the storage battery.

A boiler with a capacity for evaporating 4,000 lb. of water per hour is provided for heating the train and engine-man's cab. The boiler and water storage tanks are located in the middle of the cab and occupy a relatively large proportion of the space. The tank for fuel oil is located directly beneath the boiler, and the water tanks, two in number, just fore and aft of the boiler.

Two pantagraphs of the double sliding shoe type are provided. These are raised by air and lowered by gravity.

All cable is in steel conduit, and all exposed connections are solid copper bar or strap.

Mechanical Design

This locomotive has been designed to possess certain mechanical features which have developed through years of experience with steam locomotives. The cab has the boiler, water and oil tanks, storage batteries, air-compressor, resistors, motor-generator set, and the heavier parts of the control equipment, concentrated between the center pins. The driving motors are mounted above the axles on the running gear, thus getting the weight well inside the wheel base, but placing it relatively high. The height of the center of gravity of the complete locomotive is 68 in., a value that corresponds well with that of a steam locomotive. The height of the center of gravity of trucks with motors mounted is 43¾ in.

The quill drive, which is a further development of the one used on the New Haven locomotives, gives each driving axle perfect freedom to move vertically the full distance permitted by pedestal jaws without affecting the motors or frames, except through springs. The only "dead" weight carried is the weight of the wheels, axles, journal boxes and spring clamps which are rigidly fastened together, and 770 lb. for the journal boxes. This weight with the larger diameter of drivers (68 in.), and the total weight of 56,000 lb. per axle, gives a combination that is much better than has been considered very good practice on steam locomotives.

The cab rests on spring-supported plungers which are in series with the main semi-elliptic springs. The cab is protected against bumping strains by floating center pins, which, while held rigidly against lateral motion, are cushioned against longitudinal motion by heavy springs. It has been the practice heretofore with this general type of locomotive to have one center pin rigid in the running gear frame and allow the other one to move freely in a longitudinal direction. It is felt that it is much better to allow a slight relative motion between the two center pins, but to prevent the bumping shocks by spring cushioning.

Comparative Data for the Two Locomotives

	General Electric	Westinghouse
Total weight	521,200 lb.	550,000 lb.
Total weight on drivers	457,680 lb.	336,000 lb.
Non-spring-borne weight per driving axle	9,500 lb.	7,800 lb
Length over-all	76 ft. 0 in.	88 ft 7 in.
Height over cabs	14 ft. 11⅝ in.	14 ft. 6 in.
Height over pantograph, locked down	16 ft. 8 in.	16 ft. 7⅞ in.
Total wheelbase	67 ft. 0 in.	79 ft. 10 in.
Maximum rigid wheelbase	13 ft. 9 in.	16 ft. 9 in.
Diameter of driving wheels	44 in.	68 in.
Diameter of idle wheels	36 in.	36 in.
Heater capacity	4,000 lb. steam. per hr.	4,000 lb.
Water capacity	30,000 lb.	25,500 lb.
Oil capacity	6,000 lb.	750 gal.
Compressor capacity	150 cu. ft. per min.	150 cu. ft. per min.
Number of motors	12	12
Type of motor	(Bi-polar) GE-100	(Twin) 4-pole

	General Electric		
Locomotive rating:	Tapped field	Full field	Westinghouse
Total horsepower, one-hour motor rating	3,480	3,380	4,200
Total tractive effort one-hour motor rating	36,000	46,000	66,000
Speed, miles per hour	36.2	27.5	23.8
Total horsepower continuous	3,200	3,200	3,360

* * *

In the Milan Freight Yards During the Recent Italian Railway Strike

An Electric Road of Years Ago

By E. C. Meilloret

LOOKING back over the years I cannot help being amazed at the wonderful progress that has taken place in electric railroads. Way back in 1888 it was my good fortune to be employed on the first trolley road in the state of New York. The line was known as the Jamaica & Brooklyn Electric Railroad, and plied between East New York and Jamaica, a distance of about six miles. Now it is a part of the Brooklyn Rapid Transit System.

Originally, the road had been a horse-car line of the most primitive type, and all that could be said for the service was that they used to run a car once in a while.

The roadbed—don't talk about it! In the first place it was not much more than a good sized farm road running through hilly country. Certainly it was a great credit to Charles J. Van De Poele to have risked so much to equip that particular road, but he was a true optimist, and I can well remember when he told me that the greater the obstacle the more determined he was to overcome it—and he generally did.

In those days dry wood was considered a very good insulator and no doubt while the weather was dry, leakage was not excessive. Unfortunately, when it rained, conditions were far from satisfactory. The running rails were bonded with No. 10 galvanized iron wire and it did not take very long for trouble to begin right there.

Under such conditions as these it was quite problematical how long the current would be kept on a line, and so a five-light cluster was installed at the most important points with a sign reading "Road is running only when lamps are burning."

However, Mr. Van De Poele was working and working hard and within a remarkably short time he got things straightened out so that the road ran along pretty well.

It might be well to say a few words about the cars. The only motor on the cars was a 15-hp. Van De Poele motor which stood upright on the front platform. There was a jackshaft underneath the motor just below the floor line which received the power from the pinion on the armature shaft, a large gear coming up through the floor. From the jack shaft to the axles, or rather to the front axle, the power was conveyed to a sprocket chain. In place of a controller there was an ordinary rheostatic starting box located on the top of the motor, and the reverser—oh, my—it was operated by simply reversing the angle of lead of the brushes.

One day I fell a victim to what two fellows called a "practical joke," although I must confess that I could not quite see it that way. It had been very stormy during the night and the snow had formed drifts which made it very hard to operate the motor. I was to meet a certain car that morning at a certain place in order to help out a green motorman, but on account of the storm I was unable to get there on time. I made up my mind that I would wait for them on their return trip as it was not very far from the terminal. To my surprise I saw the green motorman walking back toward the power house. Not suspecting what had happened to the car, I asked him what the idea was and where the car was. He gave me a more or less plausible reason for going back to the power house, and said he knew I would come along any minute to take the car to the terminal. The car was only a short distance up the road and I could see the conductor waving at me to come along. Of course, the whole thing looked very fishy to me, but my duty was on that car, so on the car I went. I took my seat at the side of the motor with my hand on the starting box, threw the brushes in the forward position and awaited "two bells." Then the fun began! As soon as I turned on the "juice" the entire cab was one mass of smoke. I am not quite sure whether I saw Mars, Saturn or Jupiter, but I know I went clear through a side window—glass and all—and found myself lying bleeding in a pile of snow outside of the car.

The trouble was that the other men had burned out the motor and the man who met me was going back to the power house to report. He and the conductor thought it would be fun to give me a dose of whatever might happen. You may be sure those two fellows gave me a wide berth for some time to come.

One of the greatest trouble of the road was the negotiation of two big hills, especially the one that was called Hill No. 2. Strange to say the Van De Poele motors stood the strain pretty well, but the cars that were equipped with another motor were not so successful. In fact, everyone of the motormen had burned out one or more motors on Hill No. 2. This was getting rather expensive and in order to stimulate care in handling of the motors the company posted a list of motormen showing day by day their general standing, but this did not make Hill No. 2 any the less steep and the motors kept blowing up every once in a while.

Finally, one day, I was summoned to the office and the superintendent asked me how it was that my records showed that no motors had ever been burned out by me. Of course, I had something up my sleeve, but not caring to divulge it, I simply said it must be due to care or good luck. As to the word "care" he took kindly to that, but as for "good luck" he would not hear of it, saying there was no such thing as luck, but that there was a cause for everything. He knew what he was talking about, and he also knew that I knew more about it than I cared to tell. Finally, he asked me when my car was leaving and to my surprise he came on board, stood by me and watched my every move. Of course, the game was up and I had to let my secret out. We got over Hill No. 1, with little trouble, and started going down with full power on. The superintendent kept looking at me and at the controller and wondering why I kept the power on when going down hill. We were sure going at some speed and the superintendent had to hold fast to the grab handle. He said no more, but was evidently determined to see the thing through. When we arrived at the bottom of Hill No. 2, the great speed at which we were going sent us halfway up the hill on momentum alone, of course, using much less current. But to my dismay a woman was standing by the roadside about halfway up the hill. What was I do to? Spoil the game and risk burning my motor—or stop and pick up a passenger? I was game to the end and on went the car. Of course, I was looking on the other side of the road when we shot past the woman and I did not see her. But the superintendent did and he asked me why I did not stop? So I made a clean breast of it and told him I thought it was cheaper to lose a nickel than the chance of losing a motor. He said nothing, but a few days after signs were put up stating that cars would not stop on the hill or rather between the two hills. The motormen were each required to make one trip with me and that was the end of our troubles with Hill No. 2.

The country around there has long since been graded. The hills have been used to fill the valley between them and the road is now so level that I can scarcely locate the place where I failed to stop for the passenger. I hope she has long since forgiven me.

* * *

An Interesting Type of Board Walk Required by Floods in the Ohio River District

Protective Features of Various Controllers

Safety Devices Operate When the Mechanical Load Becomes Too Heavy for the Electric Motor

By Gordon Fox

THE first function of a controller is to make possible the effective use of a motor. The second function is to protect against damage and abuse. Protective features are in the nature of additions or ramifications upon the elementary needs for the purpose of extending the service which the control may perform.

Motors are constructed in various sizes and types, each having limitations in its ability to convert electrical into mechanical energy. These motors are ordinarily connected to systems which can supply electric energy far beyond that which the motor can convert. The machinery which is driven by a given motor is designed with ability to transmit the amount of mechanical effort which that motor should properly supply. A great excess of electrical input into a motor will damage the motor, by burning at contacts or by overheating. An excess of mechanical output may damage either the windings or mechanical parts of a motor due to the excessive stresses. It may also damage the driven machinery for like cause. The rating of a motor is a nominal matter. Most motors can and will convert energy much in excess of their rating. In order to prevent damage to both motors and driven machines some means is desirable to limit the electrical input and mechanical output. This may be done either by disconnecting the motor entirely from its source of electric power or by modifying conditions to decrease the load. The more common procedure is to open the motor circuit when the load exceeds the safe prescribed value.

Momentary extreme loads may damage a motor either by flashing or by excess mechanical stresses. A motor may also be damaged by sustained overloads which are insufficient to damage it except by heating. It is desirable to permit such overload to be carried for short intervals but to prevent their continuance to an extent sufficient to overheat the motor. This is ordinarily accomplished by use of a protective device having a time lag sufficient to prevent operation on momentary peaks yet operative under sustained overloads.

A motor which is not overloaded may be damaged by burning or overheating resulting from insulation failures or accidental contacts which short circuit portions of the windings. If these faults are such as to cause excessive current intake from the power lines, the overload protection serves also as a means to limit the damage resulting from the fault. Some faults, such as a short circuited armature or rotor coil, may not cause the protective devices to operate as excessive currents are local to the faulty coil and do not pass through the protective devices.

If a motor is operated on a circuit which is either normally or accidentally grounded, a ground in the motor or controller may cause a short circuit or some important portion of the circuit may be "shunted" or bridged around by the ground. The protective devices may serve to afford a measure of protection against grounds, their efficiency depending largely upon their character and their location in the circuit.

It has been previously set forth that large motors of any type should not be started from rest by connecting them directly across the power lines, it being necessary to modify the electrical conditions during the accelerating period. When a motor is running, its controller is normally on the "on" position. If the power is interrupted and again established before the controller is returned to its "off" position, damage may result to motor controller or machine. To prevent this occurrence most controllers are provided with a "no voltage release" feature which causes the controller to return to off position when the circuit is interrupted or when the voltage falls to a low value.

If an automatic controller is equipped with a "no voltage release" feature, it will return to "off" position upon interruption of power. If the master switch remains "on" the controller will again start the motor upon return of power, the starting operation being normal. This is a desirable feature for many installations such as fans and pumps. It is undesirable in cases where a workman might be working on a machine automatically starting as above described. To prevent accidents from this cause many automatic controllers are equipped with a "no voltage protection" feature. This is similar in action to the "no voltage release" except that the controller will not automatically start the motor upon return of power after an interruption, it being necessary for the operator to manipulate his controller to accomplish this.

In the case of many driven machines a travel occurs, the permissable travel being limited. It is not always safe or may not be desirable to expect the operator to always stop the machine within the safe limits of travel. In such cases it is customary to provide a "limit switch" which is a means for automatically stopping the motor before the limits of travel are exceeded. Limit switches may interrupt or change connections in the motor circuit, handling the load current. More commonly they are arranged to make or break contacts in the auxiliary circuits of the controller to govern the action of the controller and cause it to stop the motor.

Ordinarily, limit switches merely cause the motor circuit to be interrupted so that the motor will stop. In some cases they cause a dynamic braking circuit to be made, quickly bringing the motor and machine to rest. In some cases they are arranged not to stop the motor but to automatically change the control circuits or conditions to bring about a change in speed.

In some cases it is possible for a motor to drive a machine at a speed exceeding either the safe or the desired rate. In such cases a speed limit switch is sometimes used, this comprising some type of flyball device arranged to cause a circuit to be made or broken. These switches ordinarily handle only auxiliary circuits.

A controller may comprise a number of units. These units must be so manipulated as to produce the desired connections and electrical conditions. There are many combinations possible which are not desirable and which will cause short circuits or other improper conditions. In order to eliminate the possibilities for improper operation of the various units which make up a complete control it is the practice to provide interlocks. These interlocks may take the form of mechanical connections, such as levers, preventing units from possible operation out of sequence. They may also take the form of auxiliary electrical contacts which serve to open certain circuits when other circuits are closed.

Interlocks may be provided between the units of a single controller as in the case of a control for a wound rotor induction motor where an interlock may prevent closing the primary circuit when the secondary resistance is cut out. Interlocks may also be installed to tie together separate controllers governing motors handling related functions. For instance an arrangement may be made to stop the motor handling the feed to a given machine if the process motor itself is stopped.

Electrical motor control equipment may be considered as falling in two general classes, namely, motor starters and motor controllers. A starter, as its name implies, is arranged merely for starting and accelerating a motor to its running condition at intervals. A controller may be arranged for starting, stopping, reversing or other manipulation and is ordinarily under the frequent direction of an operator.

Both starters and controllers may be further considered as of two types, namely, direct and remote. In the direct type the device handled by the operator carries and controls the main motor circuits. In the remote type the operator handles only a push button or master switch carrying control circuits. The main motor circuits are handled by a device remote from the operator. Some remote starters or controllers are built to be operated pneumatically by means of switches closed by air operated mechanisms. Much more commonly the remote controllers are operated by means of electro-magnets or solenoids. These controllers are commonly called magnetic controllers.

A magnetic controller may be either automatic or non-automatic. In a non-automatic controller each element responds to the master switch, all action being governed entirely by the operator. In an automatic controller the action is governed entirely or in part by means which are quite independent of the operator.

Automatic controllers and starters are built in great variety to accomplish a wide range of purposes. Nearly all of them include, in common, some means of automatically limiting to a safe value the rate of acceleration of the motor or motors they control. This may be accomplished in many ways. The methods may be broadly classified as follows:

Time element principle.
Current limit principle.
Counter voltage principle.

In the time element type a dash pot is more commonly depended upon, in some form. In the current limit type switches or relays are provided whose action is governed by the motor current. In the counter-voltage types the acceleration is governed by the counter-voltage generated in the motor armature as it attains speed. Some controllers combine two or more of the above principles in their make up.

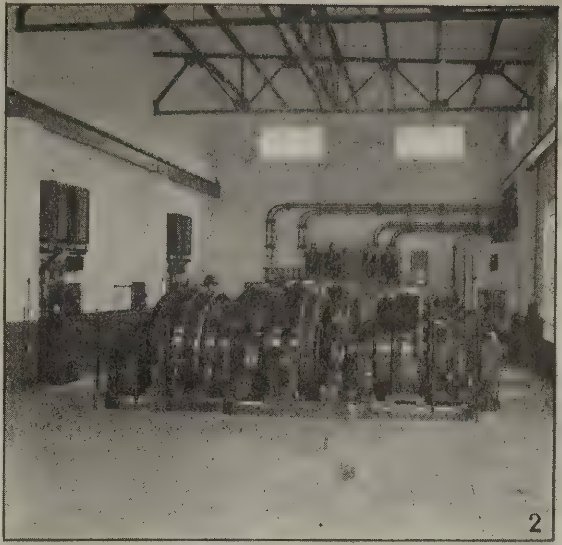
In the next article of this series a number of photographs will be shown illustrating some of the various types of manually operated controllers in common use.

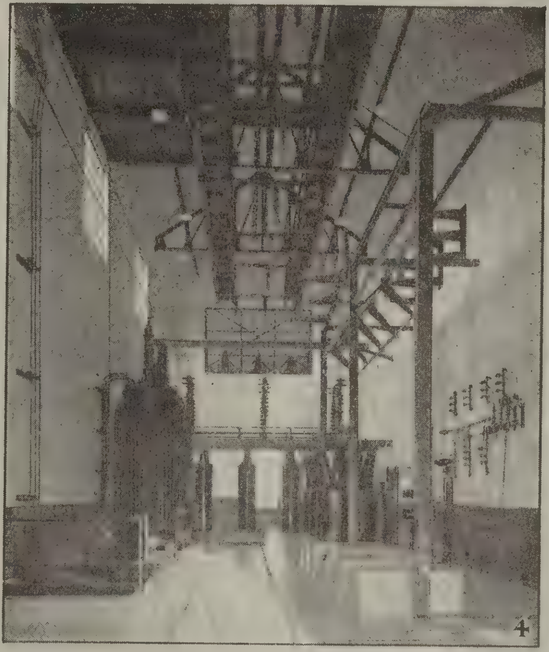
St. Paul Opens New Electrified Section

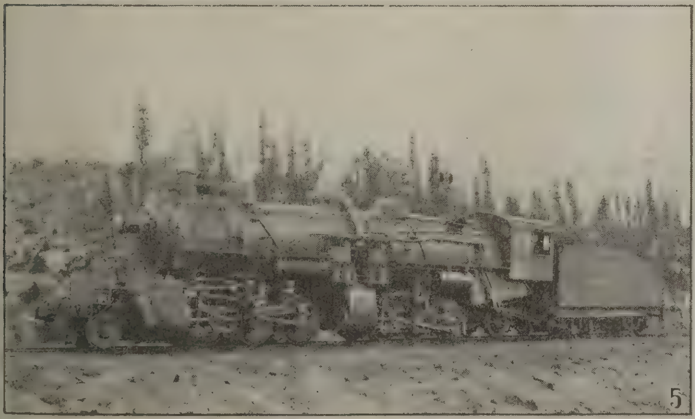
The electrification of the Coast division of the Chicago, Milwaukee & St. Paul has just been completed in final details. It adds 207.4 miles to the 440 miles previously electrified in Montana on the Rocky Mountain and Missoula divisions, making a total of 647.4 miles of the St. Paul line now operated electrically. This newly electrified division runs over the divide of the Cascade range, and takes in some very heavy grades, the maximum being a 17-mile 2.2 per cent from the Columbia river to the west and a 19-mile, 1.7 per cent from Cedar Falls east to the summit. The operation of trains by electricity on the Coast division was formally started on March 5. This division extends from Othello, in central Washington, to the shops in Tacoma on the Puget Sound end. The Rocky Mountain electrification extends from Harlowton, Mont., on the east, to Avery, Idaho, on the west. Between Avery and Othello is a stretch of 212 miles yet to be electrified.

The 3,000-volt power is supplied from eight substations about 30 miles apart along the route, power being furnished by the Inter-Mountain Power Company, which company in turn purchases power from the hydroelectric plants of the Washington Water Power Company and the Puget Sound Traction, Light & Power Company. All of the electric current used in the operation of the trains is generated from water power. The power furnished to the western electrified section is taken from the Snoqualmie plant of the Puget Sound company at the west end near Seattle, and from the Long Lake plant of the Washington Water Power Company on the Spokane river. The Snoqualmie plant is one of four owned by the Puget Sound company. It has a capacity of about 26,000 kilowatts. The penstocks go down a vertical shaft 268 feet into a cavity or chamber carved in the solid basalt where the turbines and generators are set up. The tail race is carved in rock also and leads to the gorge below the falls.

The General Electric Company supplied the equipment for five of the eight substations, namely the Cle Elum, Hyak, Cedar Falls, Renton and Tacoma; three of them having two motor generator sets, and two of them one each, making a total of 16,000 kilowatts. The motor generator sets are of 2,000 kw. capacity, each consisting of two compound wound 1,000-kw., 1,500-







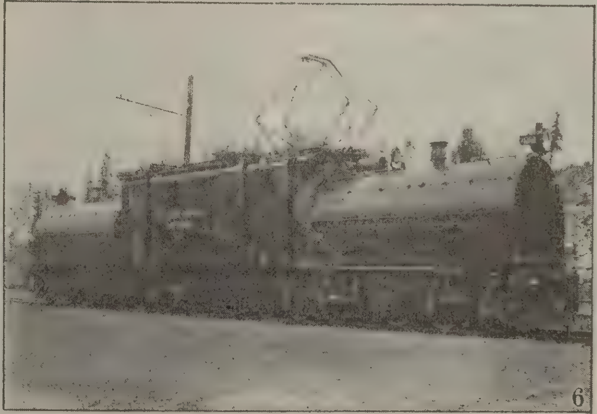


Fig. 1—Exterior of Cle Elum Substation on Chicago, Milwaukee & St. Paul Railroad

Fig. 3—Snoqualmie Falls and Power Plant in Distance. One of the Puget Sound Traction, Light and Power Company's Four Hydro-Electric Plants.

Fig 5—Type of Steam Locomotive Displaced by Electric Locomotives on New Electrification on C. M. & St. P.

Fig. 2—Interior of the Cle Elum Substation on New Electrified Division of C. M. & St. P., Showing Two 3-Unit Sets, Consisting of Two 1,000-kw., 1,500-volt D. C. Generators Driven by One 2,500-kva., 2,300-volt Synchronous Motors.

Fig. 4—Interior of the Cle Elum Substation Showing High Tension Apparatus

Fig. 6—Type of Electric Gearless Locomotive in Use on Cascade Division of C. M. & St. P.

volt d. c. generators connected in series for 3,000 volts. Each set is driven by a 2,500 k.v.a., 2,300-volt, 3-phase, 60-cycle synchronous motor, and two direct connected d. c. exciters, one 12 kw. for the field of the generators, the other 30 kw., 125 volts for the synchronous motor field.

Current is delivered to the railroad transmission lines along its right-of-way at 100,000 volts and thence to the substations which step the high tension alternating current down to 3,000 volts direct current for the overhead catenary system.

Fifteen new electric locomotives for passenger train service have been added to the equipment of the electrified sections. Five of these, which are of the bi-polar, gearless type, were built by the General Electric Company. A description of them was published in the *Railway Electrical Engineer* of December, 1919 (page 449). The remainder are Baldwin-Westinghouse electric locomotives, which were described in the *Railway Electrical Engineer* of February, 1920 (page 45). The gearless type of locomotive will be used in passenger service on the western electrified section. They are designed to haul a train consisting of 12 coaches up a 2.2 per cent grade without a helper, at a speed of 25 miles an hour.

By electrifying this division, the St. Paul has completed the longest stretch of electrified railroad in the world. This vast transportation system in its completed form operates 61 electric locomotives, including passenger, freight, and switching types. The introduction of these locomotives according to the power company's estimates has released for service elsewhere 162 steam engines, with an annual saving in fuel of 300,000 tons approximately of coal and of 40,000,000 gals. of oil, due to the fact that this railroad obtains its electrical energy supply wholly from the natural hydro-electric resources of the surrounding country.

Principles of the Lead Type Storage Battery

Charge and Discharge With Proper Care of Electrolyte Are Vital Factors in Good Operation

By H. M. Beck
Operating Engineer, Electric Storage Battery Company, Chicago

On Saturday evening, February 21, H. M. Beck, operating engineer of the Electric Storage Battery Company, addressed the car lighting men of St. Louis, Mo., on the general principles of the lead type storage battery. An exceptional, novel feature in connection with the showing of lantern slides was the actual charging of a miniature storage battery. The action which took place within the cells during charge was projected on a screen and during discharge the energy which had been stored up was allowed to dissipate itself through an electric bell.

The Lantern Slide Storage Battery

The miniature battery, used as a lantern slide, consisted of two lantern slide plates with a narrow separator between them to divide the plates into equal compartments, each of which was closed at the top, bottom and sides, thus providing two chambers into which electrolyte and two strips of lead were placed with the top portion of each strip extending through the top of the chambers. These cells were connected in series and charged from a portable battery. The rate of charge could be varied so as to illustrate excessive gassing or gassing at a moderate rate. The showing of this lantern slide demonstrated the brushing action along the plates due to the gassing which takes place during the period of overcharge, and also the circulation within the electrolyte during the gassing. This miniature battery, of course, was of very small capacity, consequently it required only a very few moments to charge and discharge it.

In discussing the general principles of the lead type storage cell, it may be of interest to know that its discovery was an accident. Years ago a Frenchman, named Plante, while conducting a series of experiments with electrolytes and metals immersed in them, the terminals of a cell or battery containing sulphuric acid and lead strips, through which current had been passing, happened to get connected in such a manner that an electrical instrument in the circuit showed a flow of electrical energy in a reverse direction, which indicated to Plante that the cells had stored up energy. The lead type cells used today, based on the Plante system, are direct successors to the original cell discovered by Plante.

Chemistry of Storage Cell

There may be some cause to wonder why this combination of lead and electrolyte is able to store up energy and give it back in the form of electric current. The chemical theory of a storage battery is very involved, in fact it has never been completely solved, but fortunately it is neither necessary nor advisable from an operating standpoint to go very far into this theory. It is far better to stop with the main facts on which the operating methods are based, otherwise there is danger of becoming confused. Chemistry teaches that when different elements or materials combine, energy is always either absorbed or given out, and when the combinations are right this energy may be made to show itself in the form of electrical current. In a storage cell which consists of the two substances, lead and sulphuric acid, the following action occurs: During discharge these substances combine to form salt of lead, and the energy from this combination shows itself in the form of electrical current. During charge the reverse action takes place. The current, in passing through the cell, breaks up the combination, driving the acid out of the plates into the electrolyte until the combination is entirely broken up. The cell is then in its original condition, fully charged and ready for another discharge.

An important fact to remember is that during charge and discharge none of the acid is lost or used up. To begin with, a certain amount of acid is contained in the electrolyte; part of this combines with the lead plate during discharge, and is all driven out again on charge, so that there is just as much acid as when the cell or battery was set up. It is important to emphasize this fact because it seems to be a general idea that some of the acid is actually used up during the working of the cell and has to be replaced. This is probably based on the fact that in the case of primary cells the solution does lose its strength and requires renewal; in the case of the storage battery, however, the acid is not lost and therefore does not have to be replaced. This is one of the most serious misunderstandings which exists in actual practice, the result being that acid is quite often added to cells when they do not need it, resulting in too strong electrolyte, and this actually injures or burns the plates. In practice there is no need to worry about adding acid to cells until it is necessary to clean out the sediment or when new plates are required, except, of course, where acid is actually lost due to an upset or broken jar.

Charging and Cut-off Charge

No matter in what service a battery is used there are three important points in connection with its operation which must be thoroughly understood. They are, first, the *charge*; second, the *discharge*, and third, the *electrolyte*. Regarding the first factor, *charge*, the aim should be to put the proper amount of current into the cells with the least amount of gassing or heating. It makes no difference as far as the life of the battery is concerned how often it is charged or what the charging rate is as long as the cells are not gassing or heating. The charging rate can be as high or low as one pleases to make it without injury. The principal point to remember, however, is to cut the charging rate down to normal before gassing takes place. Of even more importance is the *cut-off*, that is when to stop charging. This may be determined in one or more of four ways. First, by noting the *specfic gravity* of the electrolyte; second, the *voltage*; third, the *gassing*, and fourth by the *efficiency method*.

It will be remembered that during charge a breaking up action takes place between the combination of the lead and salt of lead, the latter being known as lead sulphate, which is the combination formed during the previous discharge. On charge the acid is driven back into the electrolyte, thus causing its specific gravity to rise. When the combination has been entirely broken up there is no more acid to be driven out of the plate and its specific gravity rises no higher, no matter how long the charge is continued. At the gassing point, however, care must be taken in reading the hydrometer for specific gravity measurements, because the gas in the electrolyte causes the solution to be lighter, thus the specific gravity is lower.

The second indication of stop charge or cut-off, as mentioned in a previous paragraph, can be obtained by noting the voltage of the battery or cell being charged. The battery voltage during charge behaves very much like specific gravity—that is, it raises gradually during charge and stops raising when the charge is complete. There is one thing to remember in connection with this voltage characteristic and that is this, there is no fixed value; it may vary. The thing to note, however, is that when the voltage ceases to rise the battery is charged completely.

The third indication of the end of charge is the gassing. When electrical current passes through a cell it will always do the easiest thing first. As long as there is any combination of lead and acid present it will be broken up first. When, however, this is completed, the next easiest thing is to decompose or break up the water of the electrolyte into hydrogen and oxygen; these gases appear in the form of bubbles rising to the surface along a path parallel and next to the plates. This action starts gradually and then increases rapidly until the electrolyte has the appearance of boiling water, although it does not of course, get hot. This circulation prevents stratification, that is if any water, which is lighter than acid, collects at the top of the cell it is mechanically mixed with the acid in the lower portions of the cell, due to the gassing. This action is important because water if allowed to collect at the top of the cell would freeze at a much higher temperature than when mixed with the electrolyte. The main point to remember in connection with the gassing is that when a cell begins to gas freely it is an indication that the plates are fully charged.

The fourth indication does not directly depend upon the readings of the cells, but rather upon their observed efficiency. For example, if 100 ampere hours are taken out of a cell on discharge and 115 or 120 ampere hours are put back during charge it is reasonable to assume that the cell is charged again. This method is used in various types of service, and where it is applicable it is certainly very simple. The ampere hour meter which has been designed for this purpose measures the current on discharge, then runs backward and a little slow on charge, so that by the time it reaches zero approximately enough current has been put into the cell to properly charge it. The ampere hour meter is not very accurate when the rates of discharge are low, but when the output is high it is fairly efficient. While this method of controlling the charge seems simple, due to the fact that it is not directly connected with the readings of the cell itself, it has to be checked frequently by the gravity, voltage or gassing, otherwise the meter is likely to get out of step.

In summing up the functioning of a storage cell on charge, it may be well to restate the important things to remember. These are cells that can be charged at any rate desired provided the rate is reduced to normal when the cells begin to gas, being careful to cut off the charge as soon as it is completed. This is indicated by one or more of the four indications, namely; specific gravity, voltage, gassing or efficiency.

The Discharge of Lead Storage Cells

The discharge of storage cells is more important than the charge; however, there is only one point to look out for and that is, *do not discharge too far*. An old idea seems to have caused some misunderstanding in regard to discharging cells at high rates. This old idea carried with it, that discharging cells at a high rate buckled the plates or injured them. This is not a fact. A cell can be safely discharged at any rate which the connections will stand, provided it is not run down too low. As explained in a previous paragraph, the discharge is due to the combination of the acid with the lead plate. This combination occupies a larger space than the lead itself; it therefore tends to expand the plates, and if this action is allowed to go too far it will cause them to buckle or even break; so that it is very important that discharge should not be carried beyond the proper limit. These limits are fixed by experience and the specific gravity or voltage readings are used as checks. Both of these fall during discharge and it has been found by experience that certain figures should not be exceeded or injury is likely to result. These figures vary for different types of cells, but a drop of 20 points in the specific gravity corresponds to about one-half discharge and shows that the battery or cell is ready for charge under ordinary conditions.

The Electrolyte

The care of the electrolyte is the simplest of all, and yet this is one of the points where a very large percentage of mistakes are made and a great deal of misunderstanding prevails. It will be recalled that acid is not used up in the action of the cell, unless a jar is broken or upset and the electrolyte actually lost. As far as the acid of the electrolyte is concerned the only thing to remember is to *leave it alone and never add any acid* except when the cells are being overhauled. Next in importance regarding electrolyte has to do with the *water content.* Due to gassing or evaporation, water from the electrolyte is lost and thus has to be replaced. Water alone should be used for this purpose, and when used should be of the proper purity. In regard to the latter qualification there should be no question regarding the use of distilled water, which is almost always safe. Where distilled water is not available local water may be used, providing analyses indicate that its purity is such as to permit its being used for the purpose. Analyses of such water, however, should be made by someone who is competent to pass upon its purity, in so far as such purity limits its use for storage battery purposes. As an illustration, in Chicago it has been found that Lake Michigan water is perfectly safe for storage battery use; on the other hand, analyses of water obtained from some other sources show that it is not safe for storage battery use. In general, spring, well and mountain waters are apt to be dangerous, because of the possibility of the presence of metals in solution. Rain water, if collected from a clean non-metallic roof, can generally be used. Local water should be strained or filtered, in order to keep out dirt or (when drawn from a faucet) iron scale, as this is a very dangerous impurity for a lead storage battery.

Another important thing to remember about the electrolyte is the taking of hydrometer readings. If such readings are taken with a bulb containing a tube and hydrometer it is important, first, to have the right amount of electrolyte in the tube, so that the hydrometer will float free from the bottom and top of the tube; second, the bulb which is used to draw the electrolyte into the tube should be fully expanded before the hydrometer reading is taken. It may be necessary to make more than one attempt to secure the proper amount of electrolyte in the tube to float the hydrometer with the bulb fully expanded.

Weak electrolyte, that is low gravity, is beneficial from every standpoint except as to capacity, which reduction, however, is very small. The point which is intended to be brought out here is, that there is no absolute value of gravity which must be maintained, and one must not become worried because the gravity is below standard; even down to 1170, when the cell is assumed to be charged. The real thought to bear in mind, however, is that on charge the charging is carried to a point where the gravity will cease to rise any higher and on discharge the gravity is carried to a point in keeping with safety, as explained in a previous paragraph.

Hospital Cases

Storage cells that are considered dead and those that do not give good results because of being badly sulphated, or because of other defects may be classed as hospital cases. The common error which is made when such cells are charged for the purpose of restoring them to normal condition, and the same statement may also apply to the initial charge, or the first charge given a new battery, is that the charge is not carried on long enough to bring the cell back into the normal state. It has been stated that it is not advisable to charge much above the cut-off point because of the damage created by excessive gassing, but in hospital cases the condition is different. In practice, in such cases, the tendency is to stop the charge too soon; on the other hand, in hospital cases, providing the cells are mechanically all right and no short circuits exist, it is important to remember that it is almost always necessary to be sure and charge long enough. If the charge is discontinued too soon, the trouble will not be corrected; the cells will fall behind again and fail. Any injury due to charging too long in hospital cases is slight. When such cases are being treated it is rather a difficult matter to note any change in the specific gravity and voltage readings at the point one might ordinarily consider a full charge, simply because the increase is very slow and it may take several hours to note any appreciable increase. This perhaps accounts for the many cases where such cells have not been charged long enough. Of course, it may not be advisable to attempt to bring a cell back into service beyond a point where the cost of current will more than equal the cost of new plates.

Following the talk on storage batteries, Mr. Beck, by means of lantern slides, explained the characteristic features and operation of the Electric Storage Battery Company's car lighting generator equipment.

Railroading de Luxe.— It has been the wail of some railroad employees that they work too hard for too small a wage but a story told by a Jersey Central engineer puts a different light on the subject.

This engineer, on a day off, paid a visit to a friend who runs an electric locomotive out of Grand Central. While learning the advantage of running an electric locomotive, he was invited to take a ride. When about to enter the cab he noticed a well dressed man in there and he said:

"Bill, I don't want to get you in trouble. Is that dressed up man your boss?"

"Boss nothing, he's only my fireman."

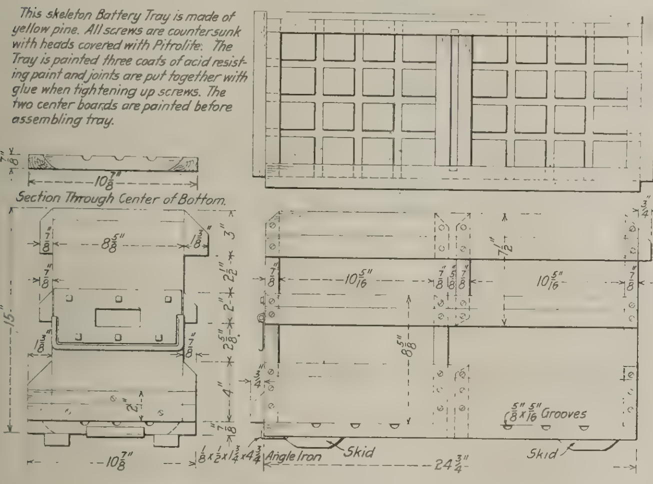
How Have the Railroads Developed Car Lighting?

Some of the Important Improvements Developed on the Rock Island are Described in this Article

By E. Wanamaker and H. R. Pennington

FOR more than a quarter of a century improvements have been made in electrical apparatus for car lighting, in an endeavor to keep pace with the demand for better and more efficient service. In this connection, electricity possesses certain inherent flexible characteristics which no other system of car lighting provides. Electrical equipment of various classes, types and designs has been developed by the manufacturers, and in almost every case certain characteristics peculiar to the particular new class, type or design, were developed because service requirements indicated the need of the new features.

The manufacturers of car lighting apparatus are not entirely responsible for this development work, for the railroads have likewise contributed. In many instances special studies have been made by individual roads to determine service requirements. Sometimes these investigations resulted in the development of apparatus designed to accomplish the function desired. During this period other work was in progress, such as collecting data and the preparation of instructions for the operation and maintenance of electric lighting systems for steam railway cars. A portion of this information has been published. But in line with this phase of the work, naturally, there developed the incentive for standardization for the benefit of maintenance and operation.



This skeleton Battery Tray is made of yellow pine. All screws are countersunk with heads covered with Pitrolite. The Tray is painted three coats of acid resisting paint and joints are put together with glue when tightening up screws. The two center boards are painted before assembling tray.

Fig. 1. Skeleton Tray for Storage Battery

Certain phases of this subject of operation and maintenance have been thoroughly discussed by various authorities. On the other hand, comparatively little has been published regarding the status of car lighting development carried on by the railroads; particularly as to the refinements of various units constituting the complete system, designed to improve the operating conditions. Because of this fact, it is felt that information concerning the activities of various roads in this connection, will be of interest.

At the present time the more important phases of car lighting seem to be divided in the following subjects: (1) Truck versus body suspended generators, with some indications of a positive drive in the future. (2) Lead versus Edison batteries, with some possibility of a more extended use of pasted plates. (3) Ampere-hour measurement versus potential measurement to determine the ultimate charge of the battery. (4) Full load train speed. (5) Equipment rating, that is, whether equipments should be for universal service or whether different ratings should be provided for various classes of service. Besides these subjects there are many others deserving mention and consideration, such as accuracy of regulation, standardization of equipment parts, etc.

It is the purpose of this article to call attention to the possible future progress in the car lighting field, and also to describe the development work which has been carried on by the Chicago, Rock Island & Pacific. The subjects are presented in the order given in the preceding paragraph.

Generator Mounting

It has always been recognized that certain desirable advantages can be secured by suspending the generator from the car body rather than from the truck. Briefly, the main advantages are, the elimination of considerable wear and tear of the generator, the suspension and the truck, due to shock, vibration, and the unbalanced condition of the truck. The accessibility of the parts for the purpose of making inspection and repairs, also some reduction in the total weight of the equipment, offer advantages. All of these features tend to reduce the cost of maintenance.

The unbalancing of the truck, by mounting the generator at one end has always given rise to serious objection by the mechanical men, who undoubtedly are the original advocates of body suspended axle light generators. On the other hand, the increased difficulty in preventing the loss or destruction of belts due to the constantly changing relation of the axle pulley to the armature pulley, especially in the earlier days of the free speed body hung generators, has given rise to more or less objection by the electrical men. Even though the advantages of the body mounting are offset to a certain extent by the disadvantages mentioned, the opinion seems to be in favor of the body mounting. But the improvements in the truck type of suspension are practically on a par with those of the body mounting, hence this fact has prevented the adoption of the latter type of mounting, at least to some extent.

With the properly designed tension device and pulleys, together with the proper belt and belt fasteners and the slight reduction in the belt tension, all of which favorably meet the conditions imposed on the belts used in connection with body mounting, it is likely that the reduction in the cost of maintenance of the generator, suspension, car truck, and inspection, will probably overbalance the advantages considered favorable to truck mounting.

At the present time there are some indications of the possibility of a positive drive being perfected, in which case the generator may or may not be mounted on the car body. A successful positive drive will certainly be a great step forward in the perfection of steam railway car lighting, because the total number of equipment failures (not light failures) attributed to belt drive is in excess of the combined failures due to all other causes.

Lead Type Storage Batteries

There have been numerous improvements made in lead batteries for car lighting, and in the accessories used in connection with them. In many cases these improvements originated on the railroads. Development in this direction, inspired by the necessity to meet operating conditions, has contributed largely to the present state of perfecion which this type of battery has reached in this field of application. An improvement which has done as much, if not more than any other, in practically

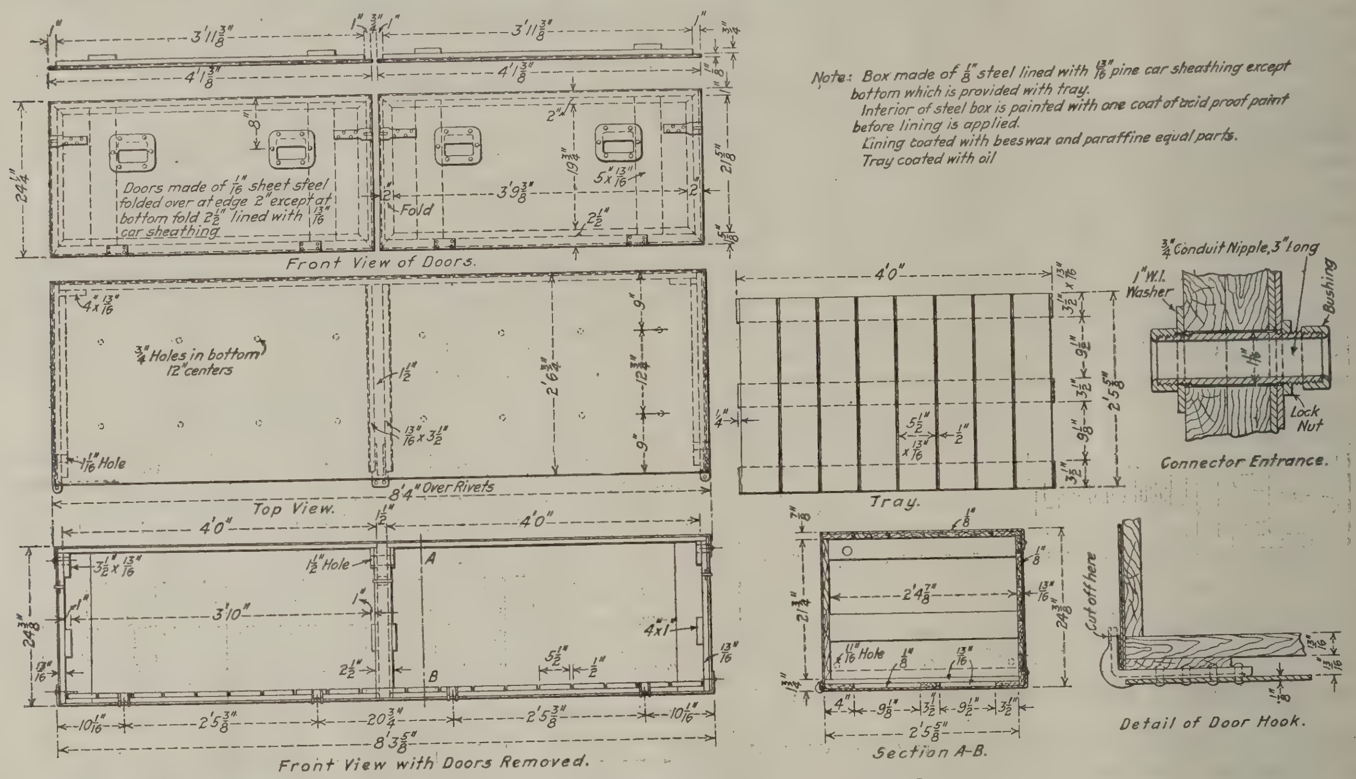

Note: Box made of 1/8" steel lined with 13/16" pine car sheathing except bottom which is provided with tray.
Interior of steel box is painted with one coat of acid proof paint before lining is applied.
Lining coated with beeswax and paraffine equal parts.
Tray coated with oil
Doors made of 1/16" sheet steel folded over at edge 2" except at bottom fold 2 1/2" lined with 13/16" car sheathing
Fold
Front View of Doors.
3/4" Holes in bottom 12" centers
1/16" Hole
8'4" Over Rivets
Top View.
1/2" Hole
Front View with Doors Removed.
8'3 5/8"
Tray.
Section A-B.
3/4" Conduit Nipple, 3" Long
1" W.I. Washer
Bushing
Lock Nut
Connector Entrance.
Cut off here
Detail of Door Hook.

Fig. 2. Box for Storage Batteries on Passenger Cars

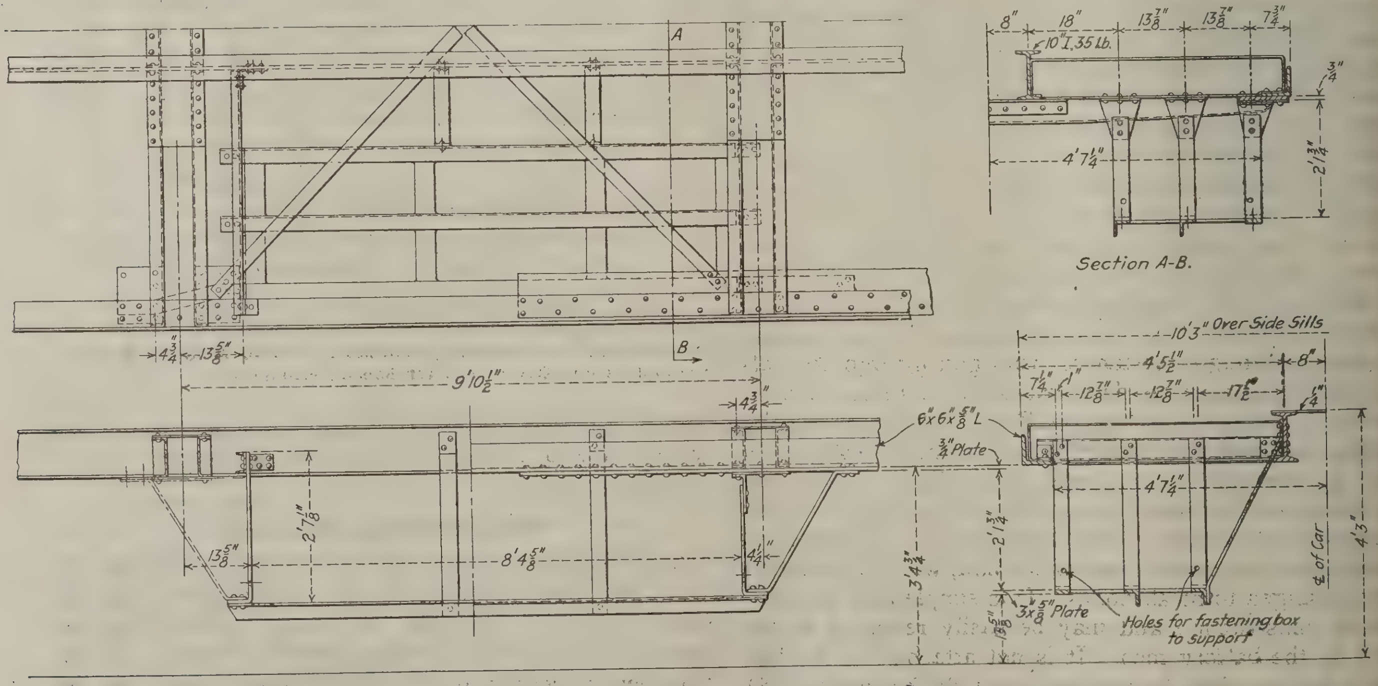


Fig. 3. Battery Box Suspension for Passenger Cars

eliminating leaky lead tanks caused by electrolytic action, is the specially designed tray known as the "skeleton tray." This improvement originated on the Rock Island. The value of this type of tray has been grossly misjudged by some of its users, because its principles have been misunderstood. The details of the tray, as used on the Rock Island lines is shown in Fig. 1. Special attention is called to the grooving in the bottom, and to the opening between compartments, which extends completely through the bottom. The purpose of the grooves and opening between compartments is to allow the electrolyte, which may find its way to the bottom of the tray to drain out, thus preventing the formation of a comparatively low resistance path from tank to tank, or from tank to ground, the cause of the electrolytic action, which ultimately results in pitted and leaky tanks.

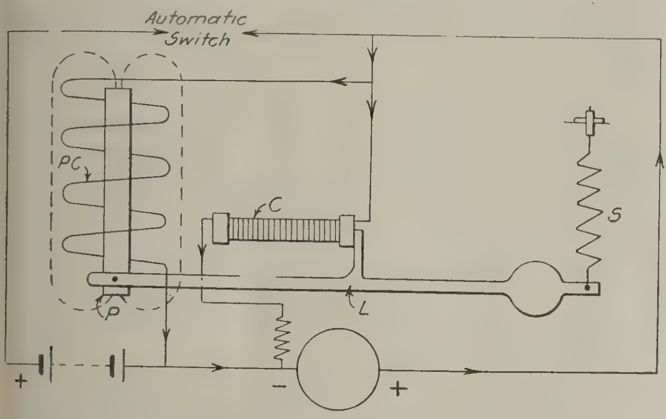


Fig. 4. Potential Control of Safety Type "F" Regulator

There are numerous other improvements which have been instituted by the operating men; these have proved of value to the successful operation of the battery and its ultimate life. Among these improvements are (1) Insulating boards placed on the front edge of cells to keep the connectors from coming in contact with lead tanks; thus preventing short circuits if the connector insulation happens to be defective. This board can be made from ⅜-in. by 4-in. material. A porcelain battery buffer is attached to each end. The board should be of sufficient length to extend across at least two cells and should be painted with an acid-proof paint. If the board is made long enough to extend the full length of each battery box compartment, the arrangement will be more satisfactory. (2) A properly designed battery box with a lining provided to eliminate grounds and also arranged to prevent foreign substances from getting into the battery solution, may be designed to meet these requirements. This box is shown in Fig. 2. In this case the battery box and the battery box suspension (shown in Fig. 3) are built as separate units. This permits the removing of the box for repairs or renewals without disturbing the battery box suspension. Attention is called to the removable floor of the box, which is a slatted rack arranged to fit all boxes. It is simple and inexpensive in construction and may be easily removed in the yard by the battery men. It is not attached to the box but is held in place by the weight of the batteries. (3) The construction of battery plates with reinforcing ribs which are intended to stiffen the plates to prevent buckling and also to distribute more evenly the current flow over the full area of the plate, is another improvement.

At the present time there are some signs of renewed activity in advocating the use of rubber jars in place of lead tanks, based on the claims that a new and better grade of rubber jar, designed for car lighting service is now available. The use of rubber jars has always been fairly successful with the Manchester type of plates, as this type does not strain the jar by expansion or growth as does the "Plante" type. The growth of plates is often the cause of fractured tanks especially during cold weather when the ductility of the rubber is greatly impaired.

The extended use of the "Faure" or pasted plates, especially positive plates, may be looked forward to as a practical possibility. Some applications which have been made indicate that the life of pasted positives with the proper battery protection can be extended over a period of three years or more. Since the first cost of pasted plates is approximately 50 per cent of that of the "Plante," it is evident that their use may show economy over the latter, especially when the reduction in weight and cleaning expense is considered. It is thought that with the use of pasted plates the cleaning period will be governed by the life of the positive plates, and as stated can be made to last three years or more. This would show a saving over the average present cost of "Plante" plates.

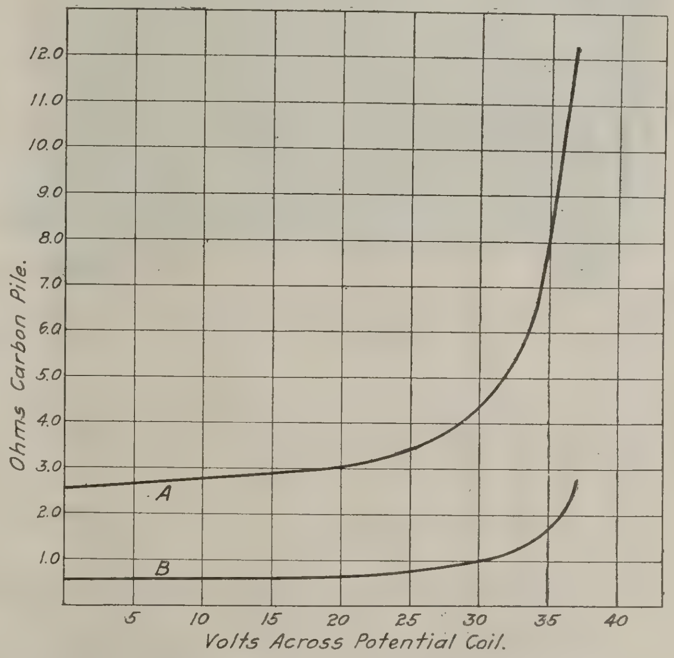


Fig. 5. Curves Showing Relation Between Resistance of Carbon Pile Under Various Degrees of Compression and Volts Across Potential Coil of "Safety" Regulators. Curve A is for Standard Regulators and Curve B is for Special Regulator.

Edison Storage Batteries

The operating man has not developed or brought about any particular improvement in Edison storage batteries since this type was introduced into car lighting service. Due to the comparatively few sets of Edison batteries in service on the Rock Island, and also due to the necessity of discontinuing the use of the standard caustic potash solution during the war, or since the latter part of 1914, when the standard solutions was replaced by a caustic soda solution, no accurate data is available on operating costs or life. But the life of the electrolyte of Edison storage battery is governed very largely upon the manner in which the battery is charged, that is, if the battery is excessively overcharged the solution will be evaporated and weakened to the extent that it must be renewed in a shorter time as compared to the life of the electrolyte of the battery if properly charged and without unnecessary over charge. This fact should not be lost sight of in the operation of this type of battery if the best results are to be secured.

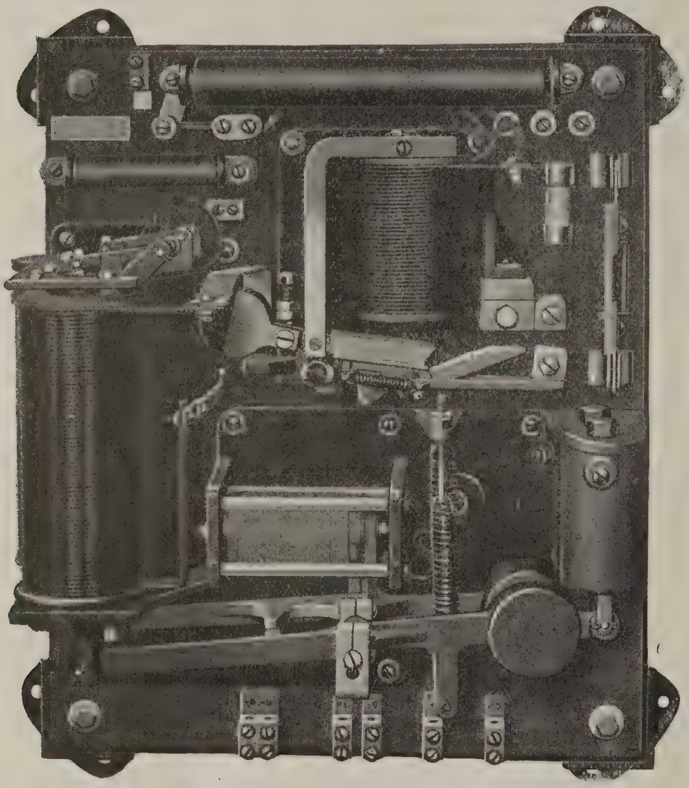


Fig. 6. Special Safety F-3 Generator Regulator Showing New Potential Coil

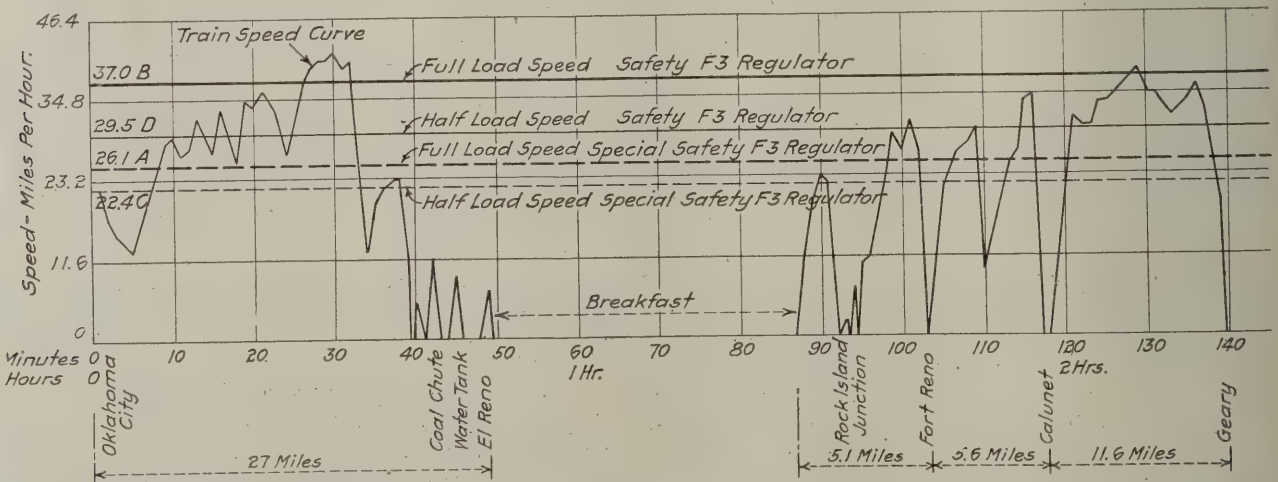


Fig. 7. Train Speed Curve for Local Service. Full Load and Half Load Speed for Standard and Special Safety F-3 Regulators.

Ampere-Hour Versus Potential Measurement

There is a considerable difference of opinion as to the relative merits of the ampere-hour method of measuring the ultimate charge of a storage battery as compared to the potential method. Each system has its advocates. The records of either arrangement vary to a marked degree because of the operating condition and care they receive. The care which the user is able to give the equipment, and the conditions under which they operate will determine which of the two systems will best serve the requirements. Progress has been made in the development of both systems. The user and the manufacturer have aided in bringing about this more perfected state, with the result of greatly improved operating records for the two systems. Unless the future reveals more convincing data as to the relative merits and advantages of one system over the other, there will continue to be a division of opinion.

Train Speed at Which Generator Should Carry Full Load

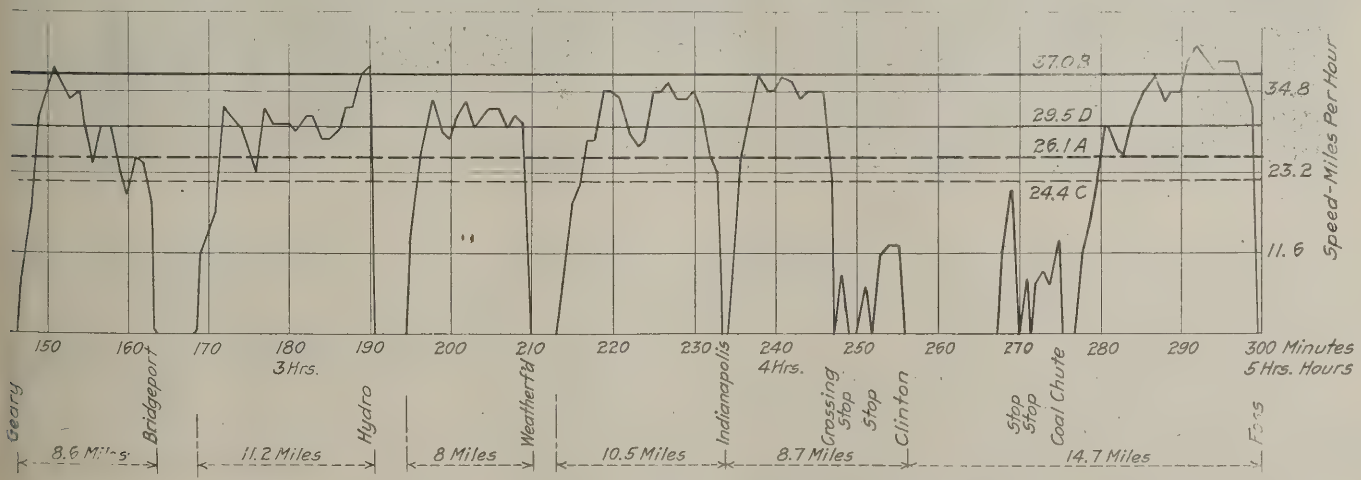
The use of axle lighting equipments for all classes of service brings up the question concerning the minimum train speed at which the generator shall deliver full load. Train speed on most branch lines as a rule, does not exceed 30 miles an hour; and most of the axle light equipments do not deliver full load under or even at this speed, the equipments being originally designed for main line service. The difficulty of operating such equipments in branch line service is therefore apparent. Even though the power demand is much less on branch line cars, use of standard equipment in this service usually results in the battery operating in a partially discharged state, due to the comparatively short time that it is subjected to the maximum charging rate or voltage.

On some roads the rolling stock is so operated that this condition can be met by applying low speed equipments to the cars operating in such service. On one road such equipments have been adopted for branch lines. These are designed so that they will also operate in main line service. For this service an exceptionally large generator is used to meet the condition.

On the Rock Island, however, this is not the case, since a very large percentage of the cars on branch lines are subject also to operation in main line service. Therefore the demand for universal equipment has become inevitable. It being undesirable to use larger and more expensive generators, an investigation was started to determine what refinements could be embodied in the present equipment to bring about full load at as low a train speed as possible, consistent with economical operation. The equipments in service at the time the investigation was started, consisted principally of "Safety" 2.6 kw. generators driven by a 2 to 1 pulley ratio, with type "D" and type "F" regulators adjusted for a maximum current of 70 amperes and 37 volts, for lead battery operation. Under these conditions the full load speed was approximately 37 miles an hour; the generator cutting in at approximately 18 miles an hour.

The fact that an increase in train speed of 52 per cent above cutting in speed was required before the generator developed full load, indicated that the normal building up of the generator was being interfered with. This interference was found to be mostly in resilience of the carbon pile of the dynamo regulator which may be explained, by referring to Fig. 4, which shows the potential control of a "Safety" type "F" regulator; the other features are omitted to simplify the explanation.

In the normal operation of the equipment the output of the generator is controlled by the amount of current passing through the shunt field which is varied by a carbon pile rheostat. The latter apparatus is actuated by the regulating coils to compensate for varying train speeds and current demands from the generator to the battery and lamps. Assume the regulator in Fig. 4 to be adjusted for 37 volts by the adjusting spring *S*. When the generator is at rest the carbon pile *C* receives maximum compression, but when the armature of the generator rotates a slight current will flow through the field and potential coil circuits as indicated by the arrows shown in the sketch. As the speed of the armature is further increased, 4 or 5 volts is developed by the generator. This voltage is impressed across the potential coil *P C* creating a magnetic field around the coil as indicated by dotted lines. This field will attract the plunger, *P* and tend to draw it in an upward direction. The strength of this magnetic field is not equal to the pull of the adjusting spring *S*, until a potential of 37 volts is impressed upon the coil. However, the force exerted on the plunger *P* due to this magnetic field at 4 or 5 volts, together with the resilience of the carbon pile *C*, is sufficient to cause the lever *L*, to move slightly, thus releasing the compression on carbon pile *C*, which in turn increases the resistance of the shunt field circuit, of which the carbon pile is a part. This change in electrical conditions retards the building up of the generator.



Continuation of Figure 7, Presenting the Second Half of the Test

As the voltage gradually increases up to the setting of the regulator there is a corresponding increase in resistance introduced in the field circuit of the generator. When the compression of the carbon pile *C* is released to a point such that its resiliency no longer interferes with the balance between the potential coil, *P C* and the adjusting spring *S*, then the generator will attain the voltage for which the regulator is adjusted.

With the standard regulator the resistance of the carbon pile under maximum compression is 2.55 ohms. This is gradually increased to 12.32 ohms by the time the maximum of 37 volts is attained. Curve *A*, Fig. 5 shows this relation. From the foregoing statements it is quite evident that the full load speed will be greatly reduced, if the introduction of resistance in the shunt field circuit is eliminated to the extent that the maximum current or voltage for which the regulator is set can still be attained.

To overcome the resilient effect of the carbon pile, in order that full load can be secured at a lower train speed, a special regulator has been designed and built by the Safety Car Heating and Lighting Company for the Rock Island. This regulator is shown in Fig. 6. The only difference between it and the standard type is that the strength of the potential coil and adjusting spring has been tripled, so that the resiliency of the carbon pile would be relatively insignificant. The increase of strength of the potential coil was secured by only a very slight increase in current through it. The additional strength was secured mainly by using a semi-ironclad potential coil. Curve *"B,"* Fig. 5 shows the comparatively small amount of resistance introduced into the shunt field circuit by the resiliency of the carbon pile using the special regulator. It will be noted that the maximum resistance of the carbon pile of the special regulator up to 37 volts (the voltage for which the regulator is set to operate) is but slightly in excess of the minimum resistance of the other regulator (also set to operate at 37 volts). To avoid error, due to possible difference in carbon discs, the same set of discs were used in both regulators.

A summary of the comparative results of the two types of regulators operating in connection with the same generator and under the same conditions is shown **in** the table.

MILES PER HOUR AT WHICH VARIOUS LOADS WERE ATTAINED
STANDARD REGULATOR

Volts	Cut In	½-Load	¾-Load	Full Load
33	17.7	20.8	22.4	24.6
34		21.4	23.5	25.3
35		21.9	23.8	26.8
36		23.5	26.8	35.1
		29.5	32.1	37.8

MILES PER HOUR AT WHICH VARIOUS LOADS WERE ATTAINED
SPECIAL REGULATOR

Volts	Cut In	½-Load	¾-Load	Full Load
33	17.1	19.4	21.4	22.4
34		20.	21.6	23.5
35		20.8	21.9	23.8
36		21.6	22.7	25.9
37		22.4	25.1	26.1

NOTE. Both regulators were adjusted for the same values.
70 amperes was considered full load.
52 amperes ¾ load.
35 amperes, ½ load.

Miles per hour are based on a 36-in. car wheel with a pulley ratio of 2 to 1.

A still further reduction in full load train speed on many of the old sleeve bearing generators which have been converted to ball bearing can be effected by reducing the air gap which was necessarily large with sleeve bearings, but which is not required when ball bearings are used.

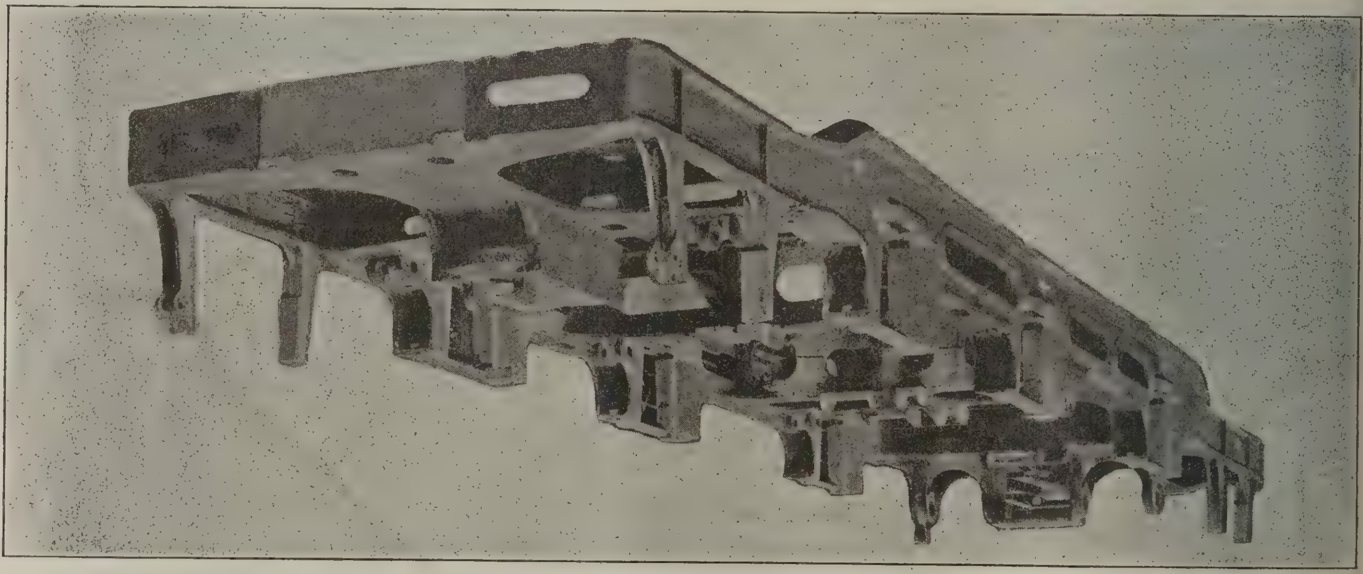
Referring to Fig. 7, the horizontal line "B" drawn through the train speed curve, which is typical of local service, represents full load speed, and line "D" one-half load speed of the standard regulator. Line "A" represents the full load speed and line "C" one-half load speed of the special equipment. A study of the difference in the full load time between the two regulators will reveal the marked advantages of the low full load speed equipment.

The question of generator rating for the various classes of service has been investigated by the committee on car lighting of the American Railroad Association. This committee among other things, is preparing a standard rating of axle generators covering the cut in speed, and sizes of generators recommended.

One-Piece Cast Steel Frames for Electric Locomotives

A notable example of the large and intricate parts which are successfully made of cast steel is the bed casting for the latest order of electric locomotives built for the New York, New Haven & Hartford. In designing this locomotive, the weight of the built up frame was found to be so great that the total weight would exceed the allowable limit. For that reason the Commonwealth Steel Company, St. Louis, Mo., was asked to submit a design. The general plan for such a casting had been worked out by the company's engineering department, but the 10 beds for the New Haven locomotives were the first to be made.

The locomotive bed is 32 ft. 4 in. long, weighs 17,000 lb., and is probably the most difficult casting of its kind ever attempted. This single unit replaces a very large number of parts, greatly reducing the weight and increasing the strength. Numerous bolts and nuts have been eliminated that become loose and allow play, especially at the pedestals. This will result in a considerable saving in the cost of maintenance and repairs. This locomotive bed strikingly illustrates the adaptability of cast steel to certain types of construction. It not only provides an irregular contour of members for clearance without sacrificing strength, but also facilitates securing various cross sections of all members, correctly proportioned in size to correspond with various stresses, at the same time providing the required flexibility in the structure.



Cast Steel Bed for New Haven Electric Locomotives

Electric Lighting and Heating began like other branches of the electrical industry, in an humble manner. As far back as the sulphur globe of Von Guericke, it was noticed that the surface of the globe glowed with a soft light which grew in intensity as the friction was increased.

Electrification of the South African Railways

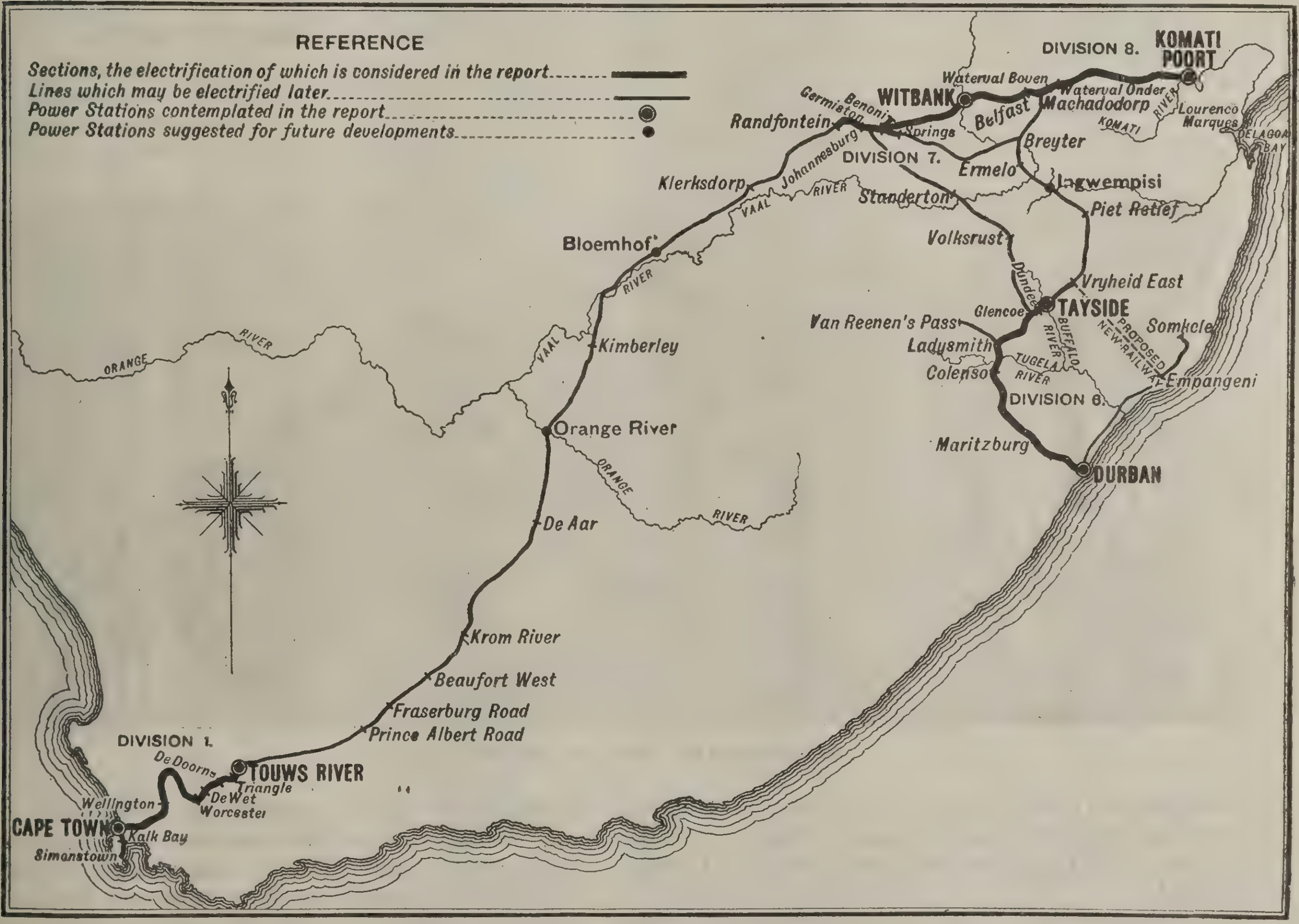
Estimated Net Expenditure of $50,000,000 to Equip 860 Route Miles—Direct Current to Be Used

By Robert E. Thayer
European Representative.

THERE HAS BEEN PUBLISHED in London recently by Merz & McLellan, consulting engineers, a most complete report on the proposed electrification of portions of the South African Railways. There is so much interest in this report that an abstract is given below:

The South African Railways in preparation for an increase in traffic has given consideration to electrification of the more congested portions of its line by means of which heavier trains can be handled at higher speeds than is possible at present. As an alternative to electrification material changes would have to be made on the road, as in some cases the traffic density has about reached the limit of that which can be handled.

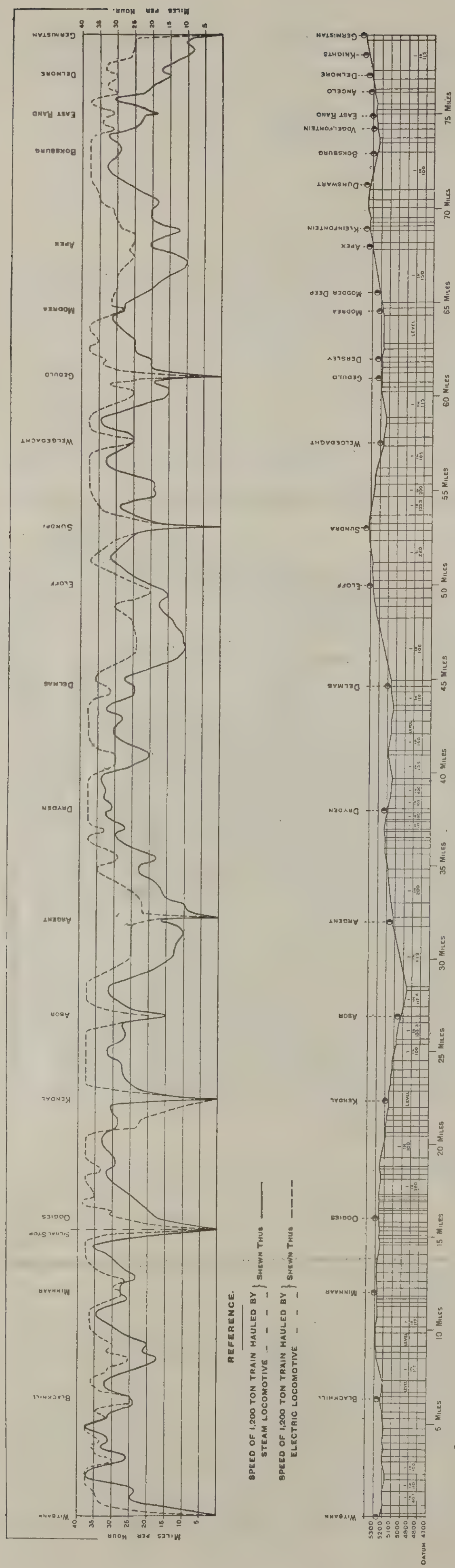
The proposed plans contemplate an increase of traffic at 50 per cent over the electrified portions with the present trackage. Four portions of the lines are considered, which involve 860 route miles and a total trackage, including yards, sidings, etc., of 1,219 miles. The estimated net capitalization involved for this electrification amounts to £11,670,485, of which £6,396,350 is the estimated cost of power stations and transmission lines. A credit of £5,033,197 was deducted from the estimated gross total expenditure on account of the equipment that would be released from actual service in the electrified portions and on account of the cost of alterations to the lines and the additional equipment that would have been required to provide for an increase of 50 per cent in traffic under steam operation. The return on the net capital expenditure is estimated to be £801,900.



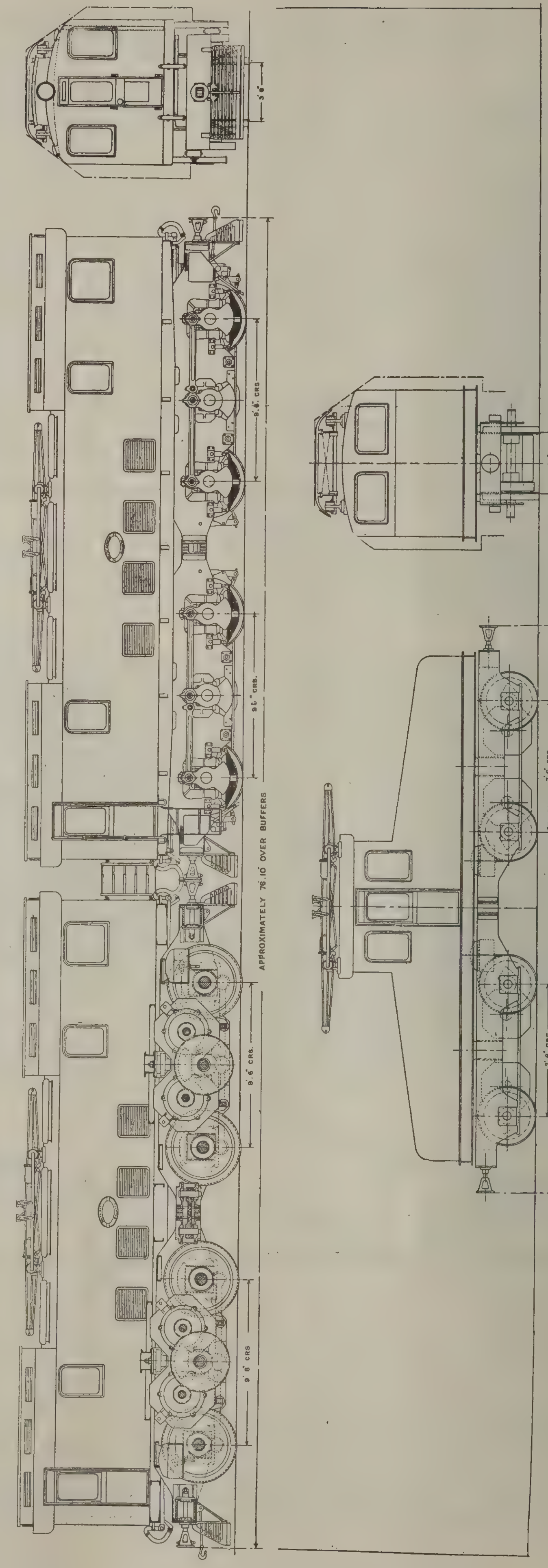
Map of South African Railways

With the existing conditions in South Africa it has been deemed practical to operate electrified portions by direct current at 3,000 volts. The power will be generated in the form of three-phase alternating current at a frequency of 50 cycles.

The report recommends electric freight locomotives



Profile and Comparative Speed Diagram for Section of Line Between Witbank and Germistan



Electric Freight and Shunting Locomotives Proposed for the South African Railways weighing 268,800 lb., having a tractive effort of 48,000 lb. for one hour and 64,000 lb. for short periods such as when starting a train. With the maximum traffic effort a factor of adhesion of 4.2 is obtained. For passenger service a locomotive of 161,280 lb. has been recommended which will have a tractive effort of 30,000 lb., one hour rating, and a maximum tractive effort of 38,400 lb. For shunting service an electric locomotive weighing 125,440 lb. has been recommended of sufficient capacity to exert a tractive effort of about 14,000 lb. at about 12.5 m. p. h., or a maximum tractive effort of about 24,000 lb. For suburban service the multiple unit system made up of combinations of one motor coach with a trailer is suggested. Regenerative braking is recommended for adoption on certain portions of the electrified lines.

Portion of Line to be Electrified

The portion of line which is considered for the present electrification is shown on the map in Fig. 1. There are four distinct portions indicated as Divisions 1, 6, 7 and 8. In all but Division 8 there are branch lines to be electrified in addition to the main line. In the vicinity of Cape Town these branch lines deal with the suburban traffic almost exclusively and the traffic on the branch lines of the other two divisions is principally freight.

The conditions of the line in Division 6, between Durban and Glencoe, are such that electrification there is very desirable. Under the present conditions the volume of traffic which is carried on the single track line has approached the limit of the capacity of the section and the increase of 50 per cent, which is traffic on which the electrification scheme is based, would require an expenditure of at least £750,000 for sidings and double tracks, whereas the total outlay required for electrification of this portion apart from the costs of power stations and transmission lines is only £952,713.

The estimated profit chargeable to electrification of this line is estimated to be £384,110. The length of line between these two points is 249 miles and the traffic consists principally of coal from the Naval coal fields in the neighborhood of Glencoe. This line contains exceptionally heavy grades and sharp curves, the maximum grade being 3.33 per cent and the minimum radius of curvature 300 ft. Durban is, of course, at sea level and the altitude of Glencoe is about 4,300 ft. with a maximum altitude between the two places of over 5,000 ft.

The main line from Cape Town to Touws river, Division 1, is 160 miles and the ruling grade is 2.5 per cent.

In Division 7 the main line between Witbank and Randfontein is 131 miles and the traffic consists almost entirely of coal from Witbank for Cape Town. The ruling gradients are against loaded traffic; between Witbank and Johannesburg it is 1 per cent and there are numerous heavy grades throughout the whole line as indicated in the profile of the line between Witbank and Germiston shown in Fig. 2.

The main line from Witbank to Komati Poort in Division 8 is 223 miles. The general character of line is similar to that of the main line in Division 6. Komati Poort is about 600 ft. above sea level and the line rises very steadily to 4,144 ft. at Waterval Onder. Between the latter station and the Waterval Boven which is not more than two or three miles air line, there is a rise of about 700 ft. which is covered by 8.5 miles of track, the ruling grade being 2 per cent.

It will thus be seen that there are some heavy grades throughout the territory which makes electrification particularly desirable.

Electrical System Recommended

As stated above, the conditions in South Africa favor the operation of the electric trains by direct current at 3,000 volts, with three-phase alternating current being transmitted to the sub-stations at a frequency of 50 cycles. Direct current meets the needs of the suburban service admirably and the results of the Chicago, Milwaukee & St. Paul electrification at 3,000 volts d. c., presents a practical example of the adaptability of this system for long distance freight and passenger traffic. The chief objection to the use of the direct current system as compared with the single phase system is that more sub-stations will be required. On the Chicago, Milwaukee & St. Paul the average distance between substations is about 32 miles and in the present case it is believed that sub-stations could logically be placed from 25 to 30 miles apart. A further objection to the direct current is that of designing the driving equipment for locomotives and motor coaches for 3,000 volts, but regardless of the fact that the narrowness of the gage of the South African railways, which is 3 ft. 6 in., presents its limitations, it has been possible to design suitable equipment. The gage, however, will not permit of placing the motors between the driving wheels, and the design of the locomotive involves the use of outside connecting rods, coupling the crank on each pair of driving axles to those of a central jack shaft which is driven through gearing by a pair of motors.

The use of direct current enables a simple construction of electrical equipment for the motor cars and locomotives in which the first cost is low and the maintenance easy and cheap. It provides for variable speeds and is well adapted to the requirements of a general system including suburban and main line traffic. In view of the several heavy grades mentioned above the use of regenerative braking is desirable. While the use of this feature is most easily accomplished with 3-phase motors it can be applied to direct current motors with the added advantage that the motors can be worked regeneratively over a wide range of speeds whereas with the 3-phase motors the current can be regenerated continuously only at one or two different speeds.

An overhead wire over the centre of each track supported at intervals by steel structures is believed the most desirable for the conditions in South Africa. The general arrangement proposed is the same as that already adopted for the electrified Sheldon-Newport branch of the North Eastern Railway in England. The contact wire is to be supported by a catanery and the line is to be divided into sections by means of section isolators.

It is planned to locate the sub-stations at Kalk Bay, two at Cape Town, Booth Junction (near Durban), Maritzburg, Ladysmith, Glencoe and at suitable intervals between the power stations which are to be located at Cape Town, Touws River, Witbank, Komati Poort, Tayside and Durban.

The location of the generating plants required considerable study. Because of the fact that the divisions to be electrified are so far from each other, with the exception of Divisions 7 and 8, this problem had to be considered separately with a view of possible extension of the electrification system.

The possible use of water power was carefully studied, but the rainfall in South Africa is very irregular and the flow of water in most of the rivers crossed by the portions of the railway under consideration is unreliable and occasionally ceases altogether. Even the Orange and the Vaal rivers have been known to cease flowing altogether and this is a common occurrence with other rivers of less importance. Thus hydro-electric plants are out of the question. Furthermore in South Africa coal at the pit is cheap and the cost of freight is low, which again favors the use of steam-driven generating plants.

In deciding the location of the power sites, the security of supply was carefully considered and they were chosen with the idea of enabling duplication of work. Thus in Division 6 it is recommended that power plants be located at Tayside and Durban. In Division 7, a power plant is to be located at a station on the Great Olifants river. In this locality, however, it is possible to draw power from the Victoria Falls and Transvaal Power Company. For Division 8, it is recommended that power plants be located at Komati Poort on the Komati river which with an increase of capacity of the Great Olifants river plant would be able to take care of that division. In Division 1 it is recommended to place the plants at Cape Town and Touws river. The Cape Town plant will provide power for the suburban branches around Cape Town and for a portion of the main line to Touws river. Although the distance between Cape Town and Touws river is only 160 miles by rail, it was considered inadvisable to depend upon a single source (Cape Town) and a transmission line of this length for a supply for the whole section and it was therefore recommended that the Touws river plant be included.

In considering the general question of power supply the report states that the engineers had in mind the possibility of supplying power to municipalities and possibly to private consumers in addition to the railways. It is believed that it would be a mistaken policy to regard railway electrification as distinct from the general use of electricity throughout the country. The majority of the power undertakings in South Africa have already adopted the 3-phase alternating current with a frequency of 50 cycles which would make co-operative working a simple matter. A splendid opportunity presents itself for co-operative working for a large power plant at Cape Town as the municipality of Cape Town will in the near future be obliged to increase its power facilities.

For the entire electrification project twenty-four 8,000 kw. units and two 5,000 kw. units have been suggested, distributed as follows:

Cape Town—Eight 8,000 kw. units.
Touws River—One 8,000 kw. unit.
Durban—Four 8,000 kw. units.
Tayside—Three 8,000 kw. units.
Great Olifants River—Eight 8,000 kw. units.
Komati Poort—Two 5,000 kw. units.

Electric Motive Power

As above mentioned it is believed advisable to use electric locomotives for main line passenger and freight trains and for switching work with multiple unit system for the suburban traffic.

Electric freight locomotives.—In South Africa where all the cars are fitted with air brakes, the controlling feature is the drawbar pull required to haul the train up the ruling grade. Investigation showed that the draft gear on some of the freight cars (which is to be systematically placed on all of the freight cars) was of a sufficient strength to enable a train of 1,800 short tons to be hauled up a grade of one per cent. This corresponds to a pull of about 48,000 lb. An electric freight locomotive was therefore designed to meet these conditions and the characteristics suggested were that it should have a tractive effort of 48,000 lb. and weigh 268,000 lb. The locomotives are designed for hauling a 1,200-ton train composed of loaded cars at a speed of about 40 m. h. p. on the level, or a train of 1,800 tons at not less than 30 m. h. p. Furthermore, they are designed to operate at a speed of 20 to 23 m. p. h. up to the ruling grade. Thus a substantial increase in general speed in freight trains is anticipated. The actual horse power of the proposed freight locomotives under these conditions works out at about 2,800 (one hour rating). This may be compared to from 1,000 to 1,400 h. p., the capacity of the present steam locomotives. The general arrangement of these locomotives is shown in Figure 3.

Electric passenger locomotives.—The average maximum load of the passenger train is about 600 tons. Platform and station accommodations generally limit the number of coaches per train to a maximum of 15 or 16. The maximum grade of any of the sections under construction on which a special passenger locomotive would be used is 2.5 per cent. Thus a tractive effort of about 40,000 lb. would be required. Inasmuch as these maximum grades are comparatively short and few, it was believed better to use a pusher in addition to the train engine and for that reason passenger locomotives of 161,280 lb. exerting a tractive effort of 13,000 lb. at one hour rating and a maximum tractive effort of 38,400 lb. were proposed. This locomotive would be able to haul a 600-ton train up a 1.67 per cent compensated grade without assistance and would be amply sufficient for all probable requirements.

Speed restrictions due to local conditions will not permit speeds higher than 60 m. p. h. and for that reason these locomotives have been designed for a normal speed on the level with a train of 15 main line coaches of not less than 55 m. p. h., or 28 to 29 m. p. h. on the grades. The design of the express passenger locomotive is similar to the freight locomotives with the addition of a leading four-wheel truck to adapt these engines to the higher speed. The use of this special design of passenger locomotive will, under the extent to which present electrification is to be carried, be restricted to Division 1, for on the other divisions there are but few places where a high speed is possible owing to the large number of sharp curves. It is therefore suggested that single-unit electric freight locomotives should be used on Divisions 7 and 8 for passenger and double-unit electric freight locomotives on Division 6, where the trains are heavy and the grades severe.

Electric shunting locomotives.—A large amount of shunting has to be carried out at Cape Town, Durban and Kendal, and for this purpose a special shunting locomotive has been recommended. It is of the double truck type, with a center driver's cab, weighing about 135,440 lb., and has a tractive effort of 14,000 lb. at 12 m. p. h. It is planned to have the electrical equipment practically identical with that of the passenger coaches of the suburban passenger trains.

Anticipated Results From Electrification

One of the chief reasons for the electrification of the South African lines was the purpose of increasing the capacity of the tracks as they now stand. The investigations were based on a 50 per cent increase in traffic. This is to be brought about by the increase in the average speed at which the trains will be operated and by increasing the train load so that greater tonnage can be hauled with a few number of trains. As most of the sections under consideration are single track lines, a reduction in the number of trains and an increase in speed will produce a great improvement in regard to delays at stations.

With electrical operations the average speed of the two different classes of traffic will be more equal than it is at the present time and there will be less necessity of side tracking the slower traffic. An example of what this means on the run between Witbank and Germiston is illustrated by the diagram in Fig. 2. The full lines show a record of an actual test with a steam locomotive commonly used on this line loaded to 600 tons, and the dotted lines show the calculated speed for the same load with an electrical locomotive. Electrically hauled trains will take 2 hours 40 minutes, exclusive of stops, as compared with 3 hours 45 minutes for the steam train, or a reduction of nearly 30 per cent in the running time. The saving of time on the other sections is even greater. For instance, the running time for fast freight trains from DeDorns to Touws river, allowing one intermediate stop for water, is at present 2 hours 24 minutes, whereas with the electrically operated train the same distance will be covered in 1 hour 12 minutes. In passenger service the present running schedule between Cape Town and Touws river is 7 hours 50 minutes, whereas under electrical operation the schedule is 5 hours 45 minutes.

In regard to the suburban passenger trains operated under the multiple-unit system it is the universal experience that such improvements in traveling facilities produce a larger volume of traffic, which is due to a growth of the population in the remoter suburbs and to more frequent use of the improved services.

With the increase of speed less equipment will be required to handle the same amount of traffic. There will be a reduction in the amount of coal consumed, with the accompanying decrease in the number of cars used for the transportation of company coal. There will be an increase in engine mileage. In the case of the freight service between Glencoe and Durban the yearly mileage of the electric locomotives would be at least 70,000 miles. Thus fewer electric locomotives will be required. In this respect it is estimated that with 262 electric freight, passenger and shunting locomotives and 136 motor coaches, 448 steam locomotives would be available for sale or service elsewhere and that the 152 steam locomotives would not have to be purchased in order to deal with the 50 per cent increase in traffic the 262 electric locomotives and 136 motor coaches are expected to handle. In addition to this, electrification would, on account of increase in speed and the reduction in fuel consumed, make unnecessary the purchase of 1,038 new 40-ton freight cars, or their equivalent, which would be required for the demands under steam operation.

The decrease in annual train mileage, considering the estimated 50 per cent increase in traffic, is well illustrated in the through freight service. With steam locomotives it has been estimated that train mileage of the four divisions would be 9,846,800 miles, and with electric operation this would be 6,890,610 miles, or a saving of 2,956,190 train miles, or 30 per cent.

The saving in working expenses involves a comparison of the cost, under steam operation, of coal, water, wages of train crews, engine house expenses, lighting and heating, locomotive repairs, depreciation with, under electric operation, the cost of electrical energy, wages of train crews, engine house expenses, repairs and depreciation of the locomotives and motor equipment, depreciation, maintenance and working expenses of the sub-stations and the maintenance of the track equipment necessary for electrification. On the four divisions the estimated profit for electrical operation amounts to £801,900.

Capital Expenditures

The various items of capital expenditure involved in the electrification of these lines involves the cost of new rolling stock, electric locomotives, etc., the cost of the distribution system, the cost of the sub-stations and the cost of the power plant and transmission lines. There are other items, such as alterations to engine houses, telegraph and telephone lines, lengthening of sidings, etc. The net outlay on rolling stock is obtained by deducting from the gross expenditure for the new electric locomotives or train equipments the value of the existing steam locomotives displaced, the new steam locomotives that would be required for the additional traffic under consideration, the new wagons that would be unnecessary to purchase on account of the increased speed of the traffic, and the new wagons that it would be unnecessary to purchase due to the reduction in fuel consumption. The cost of the distribution system and sub-stations present an entirely new item of expenses, from which there is nothing to be deducted.

There are, however, additional credits which enter into the present discussion, such as the cost of alterations in the track to handle the 50 per cent increase in traffic under steam working, and which would not be necessary by electrical working. A balance of these items, exclusive of the power stations and transmission lines, show the estimated net capital outlay to be £5,274,153. The cost of power stations and transmission lines had not been included in this estimate because of the possibility of purchasing power from various outside sources. However, in the working expenses interest at 5 per cent per annum on the capital required for new stations and transmission lines in event of the railroad producing its own power is included, together with a depreciation charge of 3 per cent on the power stations. The estimated capital outlay on power stations and transmission lines amount to £6,396,350. The net return on the net capital outlay, exclusive of the cost of the power stations and transmission lines, is approximately 15 per cent. If the cost of the power stations and transmission lines are included the net return would be approximately 7 per cent.

Alternating Current Theory and Practice

A Brief Practical Review of Basic Principles Prepared for Railroad Electrical Workers

By O. C. Callow

IV. Star and Delta Connections

In the previous articles it has been shown that the voltage and current are continually changing in strength and direction, these changes taking place as often as 60 times a second in a 60 cycle circuit. In order to measure the current flowing through a circuit and the voltage across it, a meter must be designed to give a steady reading which is based upon the curve produced by the change in voltage and current.

There are three distinct methods of expressing the voltage and current of a circuit—*maximum, average* and *virtual* values. The first two, however, are seldom used in practice. The maximum voltage as the name denotes is the maximum value reached each cycle in the positive and negative direction. This value, although hardly ever referred to when speaking of voltage of a circuit, is the value for which the apparatus on the system should be installed to stand. The average value of the voltage is likewise little used. It represents the average of all the instantaneous values of the voltage curve for one-cycle and is equal to .637 times the maximum.

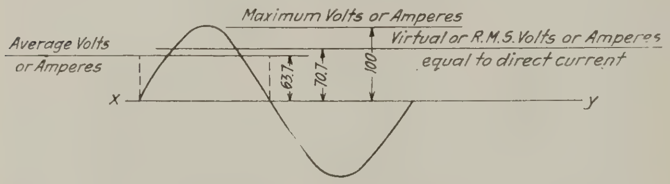


Fig. 1—Sketch Showing Relationship Between Maximum, Virtual and Average Values

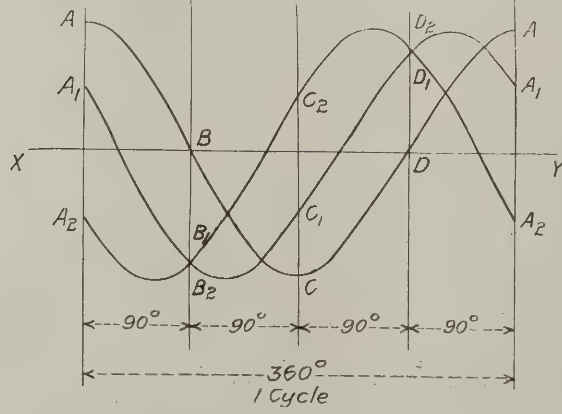


Fig. 2—Voltage and Current Curves of a Three-phase Generator When Each Phase is Connected in the Same Way

The virtual value is the one which is in every day use. This value is equivalent to that of a direct pressure or current which would produce the same heating effect, and is equal to .707 times the maximum value. It is sometimes known as the R. M. S. value, since it is really obtained by taking the square root of the mean square value of the voltage curve produced by the machine. The electro-static voltmeters which are used for measuring alternating currents actually read the R. M. S. values direct. If one of these meters were connected in a circuit where it was known that the voltage was alternating between the values of 100 volts on the negative side and 100 volts on the positive side, it would show a steady reading of 70.7 volts. A similar condition will exist in regard to the ammeter. These meters are sometimes operated by the heating effect of the current passing through them, in which case they automatically register a value which is equal to the direct current required to produce the same heating effect. A study of the curve shown in Fig. 1 will help to bring out the different values which have been just explained.

The three-phase generator as described in the preceding article was equipped with six slip rings and wound with three complete single-phase windings. This type of machine would necessitate six wires for its external circuit, which would be complicated and would not compare favorably with a two-phase four wire machine. If all three-phase generators were built for six leads there would be little use for this type of machine. Let us see what improvement can be made to reduce the number of these wires and still retain the three circuits. Fig. 2 shows the three current and voltage curves of the three-phase machine described in the preceding article. It will be noted that the general appearance of these curves is unsymmetrical for at any given instant there is more current and voltage represented on one side of *X Y* than on the other. This condition can be overcome by reversing the direction of phase *B* so that its curve will be in the opposite direction, thus giving a symmetrical curve such as shown in Fig. 3.

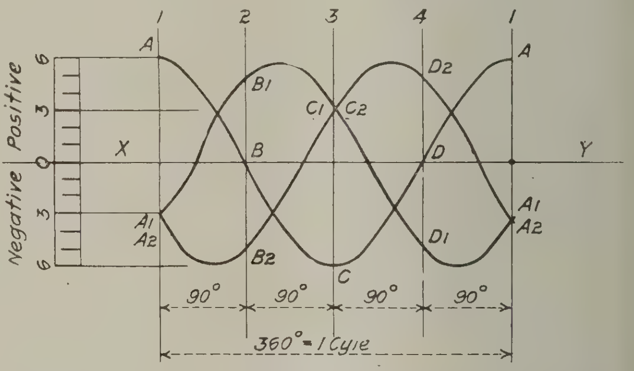


Fig. 3—Voltage and Current Curves of a Three-phase Generator When One of the Phases Has Its Connections Reversed

When maximum voltage is flowing in any one direction it will be noted that the other two voltages are each at half strength in the opposite direction. In fact, at any instant the sum of the voltages in one direction will equal the sum of those in the opposite direction, the resultant being zero. This can be understood better by referring to the scale shown in Fig. 3. In position 1 we find the value of the voltage curve *A* to be 6 in the positive direction, whereas curve *A1* and *A2* equal 3 each in the negative direction, making a total of 6. The voltages will therefore equal one another and the resultant will be zero. At position 2 curve *A* is at zero, curve *A1* has a value of 5 in the positive direction and curve *A2*, 5 in the negative direction. These again balance one another. This can be calculated for any position on the curves with the same results. It may be shown, due to this fact, that three wires can be made to transmit the current and voltage of a three-phase generator, and that only three slip rings will be required for this machine.

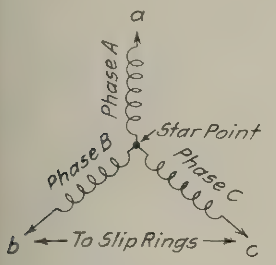


Fig. 4a

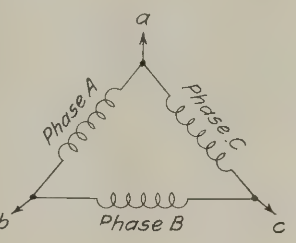


Fig. 4b

Fig 4a—Star Connected Winding With One Point in Common to all Three Phases

Fig 4b—Delta Connected Winding With the Three Phases Connected in the Form of a Triangle

There are two methods in use to connect the three single-phase windings of the generator to the three slip rings. They are known as the star connection and the delta connection. The star connection is made by connecting one end of each phase to a common point, known as the star point or neutral and the other ends of the phases *a*, *b* and *c* to the slip rings. This type of winding is generally shown in the form of the letter Y and therefore sometimes called the wye winding. Fig. 4a shows this winding diagrammatically.

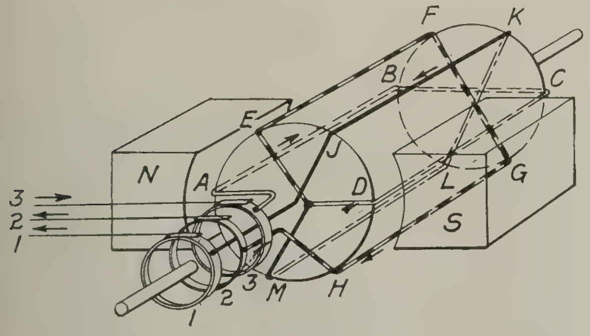


Fig. 5—A Two-pole, Three-phase, Star-Connected Generator, Having Two Conductors Per Phase

If we consider a simple two-pole, star connected, three-phase generator, having two conductors per phase, the connection can be as shown in Fig 5. At the instant shown current and voltage will be at maximum value in coil *A B C D* and will be flowing in at the slip ring *3*. In *E F G H* it will be at half value and will be flowing out of the slip ring *2*, while in *J K L M* it will also be at half value and flowing out at slip ring *1*. These values correspond to those shown in position 1 in Fig. 3. It will be noted that the coil *E F G H* has been reversed, the end *E* being connected to the star point instead of to the ship rings.

In a star-connected generator the current in each leg of the winding will be equal to the current flowing through each of the three leads. This can be shown diagrammatically as in Fig. 6. If a load of 100 amperes were connected to each line as shown, then 100 amperes would be flowing in each phase of the generator *A, A1, A2*. If the same machine was designed to generate 100 volts in each leg of its winding, it would be found that the voltage between each slip ring and therefore each line would be 173.2 volts. The reason for this increased voltage in the line over that generated in each leg of the winding, can be understood if we consider that the winding *AX*, and *A2X*, both are generating voltage to feed the lines from *A* and *A2*. If there were only these two windings and lines to be considered, it would be found that the voltage between *A* and *A2* would be 200 volts, the two windings being in series. However, we have a third phase to consider, *A1X*, which is connected in at the middle of *A* and *A2*, therefore the voltage generated in *AX* and *A2X*, will not only feed the lines from *A* and *A2*, but also from *A1*, hence the voltage between these lines will be less than 200 volts. The resultant voltage which will actually be generated between each line will therefore be the generated voltage in each winding multiplied by the square root of 3, which is equal to 100 × 1.73 = 173 volts as stated. Hence the output of a star connected three-phase generator is equal to the line current times the line voltage multiplied by √3 or 1.732.

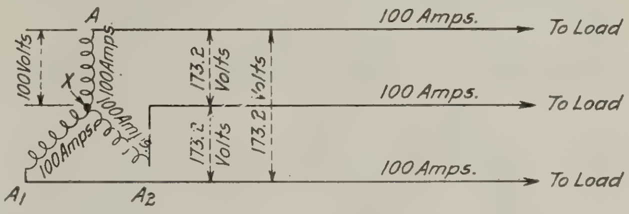


Fig. 6—Relation of Current and Voltage in a Star-Connected Three-phase Generator and in the External Circuits Connected to It.

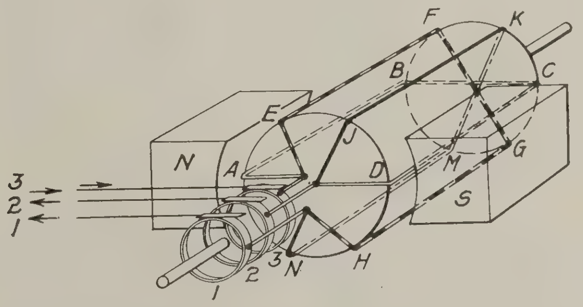


Fig. 7—A Delta-Connected, Two-Pole, Three-phase Generator With Two Conductors Per Phase

We will now consider the delta connected generator. The name is derived from the Greek letter delta, represented △, this being the form in which the coils are connected. Fig. 4b shows a diagram of a delta connection, with the three windings connected in the form of a triangle. The three corners *a b c* are connected to the slip rings and thence to the load. A delta connected two-pole, three-phase machine such as is shown in Fig. 7 having three coils, will produce current and voltage curves exactly similar to those shown in Fig. 2 produced by the star connected generator. The coil *A B C D*, will generate maximum voltage in the positive direction, which will be flowing in at the slip ring 3. In *E F G H*, the voltage will be at half value but still in the positive direction, as this coil is reversed as in the star connected machine, the current and voltage will flow out of slip ring 2. The voltage in the coil *J K M N*, will be at half strength in the negative direction, and current and voltage will therefore flow out of slip ring 1. We therefore find full voltage and current flowing into the machine at slip ring 3 and half voltage and current flowing out at slip rings 1 and 2 respectively, which is exactly similar to the star connected machine.

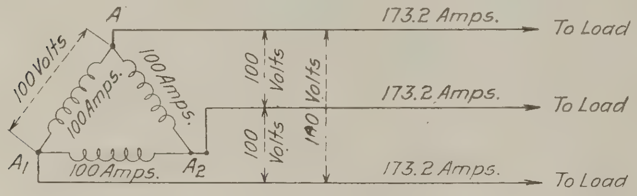


Fig. 8—Relationship of Current and Voltage in a Three-phase Delta Connected Generator and in the External Circuits Connected to It.

The relation between current and voltage in the delta winding differs from the star winding in the following manner. The voltage which is generated by each leg of the delta winding will be equal to the voltage across each slip ring and each line. This condition is shown diagrammatically in Fig. 8. With 100 volts generated in each phase of the machine, the line voltage will be 100 volts as compared with 173.2 volts of the star winding. This is due to the fact that the slip rings are connected at three equal points in the winding. With a connected load of 173.2 amperes to each line of the delta connected machine, it is found that a current of only 100 amperes will be flowing through the three legs of the winding. Thus the current in the line will be 1.73 or the square root of 3 times the current in each winding. The reason for this increase in line current is the same as previous explanation, showing the increased voltage produced in the line when using the star winding. The current in the line *A* will be produced by both the windings *A1A* and *A2A*.

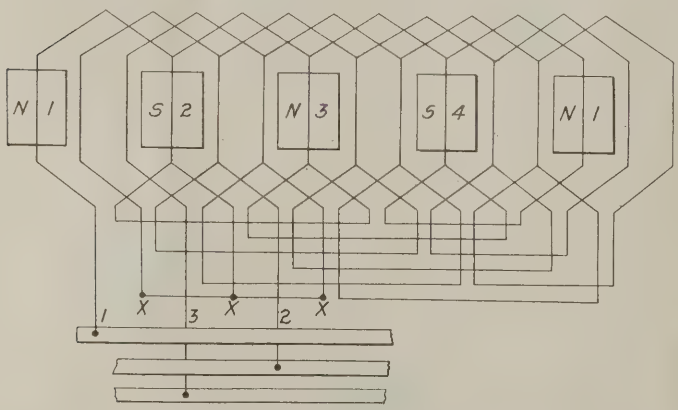


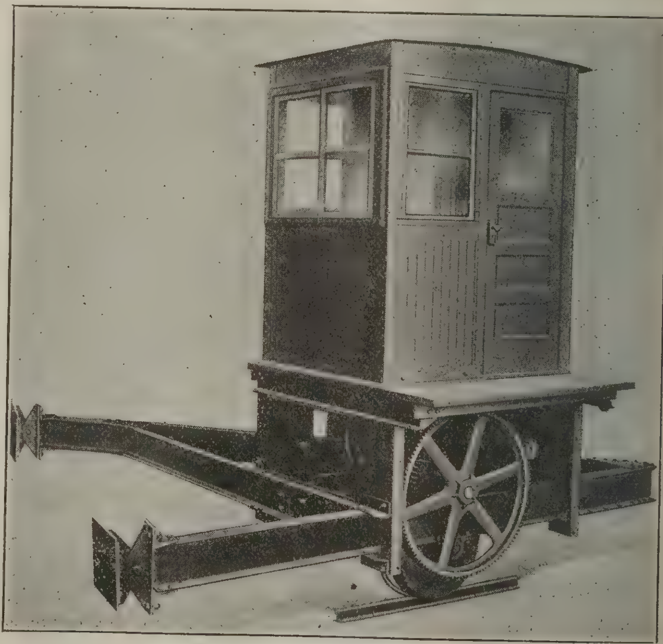
Fig. 9—The Developed Winding Diagram of a Four-Pole, Three-phase, Star-Connected Generator, Having a Pole Pitch Equal to the Coil Pitch and One Coil Per Group

It will be seen that the output of the delta connected machine is equal to the voltage times the current multiplied by $\sqrt{3}$ which is similar to the star connected machine. As a summary of the two types it can be said that the star connected machine will give a higher line voltage than the delta connected machine for the same voltage generated per phase, hence it is suited for machines of high voltage and moderate current. For the same reasons the delta machine will be more suitable for lower voltages where heavy currents are required. Given a certain three-phase winding, if delta connected, it will stand 1.732 times as much current as if star connected; however, it will only generate 1 ÷ 1.732 or .577 times as much voltage.

In designing the winding of a three-phase generator the number of coils per group and number of turns per coil will be somewhat influenced by the type of connection used, whether star or delta. With a certain output required of the machine, either one connection or the other may work out to advantage. In practice, the star connection is perhaps most common. There is no difficulty in changing the connection from one type to the other, since the winding itself will require no change, all the reconnections being made on the end connection of the coils. Fig. 8 shows a developed winding diagram of a four-pole, three-phase, star connected generator, having a pole pitch equal to the coil pitch and one coil per group. The star point is shown as *X*. It will be noted that the winding of phase No. 2 is reversed for reason shown above.

The Whiting Heavy Duty Turntable Tractor

The Whiting Foundry Equipment Company, Harvey, Ill., has recently started manufacturing a heavy duty tractor for turntables of any capacity and pit-rail radius.



The New Whiting Tractor

the main frame of the tractor is V-shaped, built up of eye-beams and channels rigidly connected and attached to the turntable by steel hinges in such a manner as to prevent any vertical movement of the tractor when a locomotive is run on or off the table. The frame is extended outside the traction wheel in order that counterweights may be applied where additional tractive effort is required for heavy conditions.

The driving mechanism consists of a variable speed, reversible heavy duty type of motor located on the top of the structural frame driving two cast steel and forged steel pinions with cut teeth to a chilled iron traction wheel. Lubrication is accomplished through or by means of compression grease cups. The brake is asbestos lined and operates in either direction of rotation. The sandbox is located directly underneath the cabin floor and consists of a steel box with a vertical swinging valve connected to a sand agitator, both the valve and the agitator being operated from within the cab.

The tractor is equipped with an enclosed wood cab in which are located the controller which is of the standard reversible drum type, the safety switch, the sanding control and the brakes. A trap door in the floor of the cab gives access to the machinery for inspection and oiling.

All wiring is in accordance with the Underwriters National Electric Code and is protected by iron conduits as far as possible. The current collector is arranged to be applied overhead or underneath the table and is enclosed in a water and steam proof housing.

Stop, Look and Listen

By Chas. W. T. Stuart

WHO was the first car lighting electrician?

Where did he get his experience and who was his instructor?

My, what a difference today!

Three hundred and eighty years ago when railroads were equipped with wooden tracks, cars were lighted by the sun and moon, and the fellow who put the candle in the first passenger car built 200 years ago is dead, and didn't leave his name. The same thing happened to the fellow who maintained the first gas lighted passenger car 153 years ago. Yes, he's dead too!

It wasn't 380, or 200, or even 153 years ago that the first electric lighted passenger car was put in service. It was only 39 years ago. During those early days the car lighting maintainers were not picked from a class of skilled electrical men. They were picked from the unskilled class of workmen such as the car cleaning department, etc. For this reason the wages were started at the rock bottom. There were no facilities of any account available and the work was rough and heavy. These poor fellows had a rough road to travel. No suitable trucks could be found and consequently batteries were carried long distances. They never dreamed of a battery cleaning room. Batteries were washed, repaired and charged out in the open. Practically the only facilities a car lighting man had were a battery handle, battery car, hydrometer, voltmeter, soldering iron, hammer and chisel. Therefore, all work was done in the crudest and simplest possible way. For instance, battery plates were straightened with a hammer and cut off with a chisel. The acid was dumped from one cell to another regardless of its chemical condition. About one man in fifty could repair a lead lining, consequently many that could have been repaired were scrapped.

In the pioneer days of car lighting by electricity, axle generators suffered more than batteries. The armature pulley nut and housing head bolts were always removed with a hammer and sharp chisel. When it was discovered that wrenches could be used for this purpose the nuts and bolt heads were badly cut up and had to be renewed. Armature pulleys were always removed with sledge hammers and crowbars. But eventually, as one fellow put it, a "Lady Finger Guy" came along with a puller for that purpose.

There was no definite time set for overhauling an axle generator. They were not inspected until they arrived with smoke pouring out of them. Then they were given attention. This attention consisted of taking a machine apart and laying the parts in the mud and dust between the tracks, renewing the damaged parts, reassembling the machine, being careful to use the hammer and chisel to tighten all bolts and nuts.

Many other crude ideas were in existence those days. For instance, if a car was found in trouble all testing was done by the use of a piece of wire only. If the circuit was closed you would get a dead short circuit and if the circuit was open you would get a violent flash. Should a fuse happen to blow it was replaced with whatever the fellow happened to have in his pocket, such as an old pocket knife, old key, iron or copper wires or a broken hack saw blade. In other words, anything that would fit was used.

Short circuits were removed by the burning-off process. This process involved closing the circuit by cutting or shunting all fuses or cutouts with a pair of pliers or a monkey wrench and then if the short circuit didn't burn off something else had to. The ends of the generator belts were cut zig-zag, with a washboard finish, as if they had caught in something and ripped off, and in a case where the belt clamps required ten rivets, four would hold it nicely. Today some of these old-timers say, "Yes, and we had better service than we have now." But this isn't so. Those days one car out of every twenty was electric lighted and the failures were so numerous they were not noticed.

It stands to reason that the efficiency of car lighting by electricity must be higher today with all the modern facilities for maintaining car lighting equipments. Look at the well equipped, lighted and ventilated battery houses of today. Equipped with acid mixing tanks and acid conveyors, plate presses, electric cranes, wash and assembly benches, lead burning outfits, electric trucks, charging and discharging panels. And the well lighted, dust proof, generator repair rooms, equipped with work benches, armature shaft and bearing presses, testing tables and racks, electric cranes, etc. Why shouldn't electric car lighting efficiency be higher today?

But there is one thing in particular the pioneer car lighting man was recognized for and that was his appearance. He was so tidy and neat about his appearance! The standard uniform was black, yes, everything was black regardless of its original color. They wore so-called 8,000-day shirts (black), so christened because of their long endurance and non-laundrying qualities. These uniforms were worn day in and day out from the day of birth until they fell off dead, without even hesitating at a laundry, let alone stopping off.

This all happened in the pioneer days, but it wasn't long before the progressive car lighting fellows discovered what a big mistake they were making and got busy. The result is that today we find car lighting electricians as a whole holding their own on a par with the other branches of the electrical department. The so-called slouch in appearance as well as slouch in workmanship has disappeared. And I say without a doubt that this spirit and desire on the part of the car lighting electrician to advance and get ahead is responsible for the success and efficiency of car lighting today.

By the equality of wages and working conditions the electric car lighting department is attracting the skilled electricians of the other fields of electricity, and before long it will have more prestige with the electrical engineers of the other fields also.

As car lighting advances the roll of employes increases, and I want to say to these new men that it is their duty to grasp this spirit of energy, progress and advancement and keep pushing ahead. Don't you be one of the so-called dead wood, because if you lay back in peaceful slumber you will drift into the habit of slouch in both your work and appearance and undo the good work of your fellow workmen. There is no excuse for you to wear the cloak of a strong-back and weak-minded car lighting electrician because there are books, schools and modern facilities at your hand that the poor fellows did not have in the pioneer days.

Let us take your work of today for example. Did you honestly do your very best? Were you careful not to slip up on just a very small part of your work? Were you careful not to scrap anything that could have been repaired, thereby wasting money and increasing the cost of car lighting? Don't say that Jim Jones and Henry Smith do bum work and get away with it. That may be true; they may get away with it for a time, but sooner or later if they don't discover that they are unfair to themselves as well as everyone else, their superiors will, and then justice will step in and ahead you'll go It never fails! The progress of car lighting is not going to stop, because there are too many progressive fellows with their shoulders to the wheel with a determination to make a higher standard and efficiency of car lighting by electricity.

General Electric Company Leases New Plant

On March 17, 1920, the General Electric Company leased, with option to purchase, the forty acre war plant of the Remington Arms Company at Bridgeport, Conn. The transaction involves about $7,000,000.

The plant was built in 1915-16, and is of the latest type of construction, being located in the industrial center of Bridgeport, in what is known as the East Side. The floor area in the buildings is 1,555,257 square feet, or about thirty-six acres.

The buildings are divided into four groups consisting of thirteen five-story buildings and drying kiln, five one-story buildings, guards quarters, and two storage buildings. The buildings are all on the same level, and connected on each story with a corridor which runs through all of the thirteen main buildings, greatly facilitating the delivery and movement of material.

The Remington Arms Plant at Bridgeport, Conn., Leased By the General Electric Company, March 17, 1920

The plant is expected to be in full operation by April 15, when the General Electric Company will employ many thousand people, all of whom can be easily housed, as the facilities already exist. It is not yet known just what products will be manufactured in the new plant.

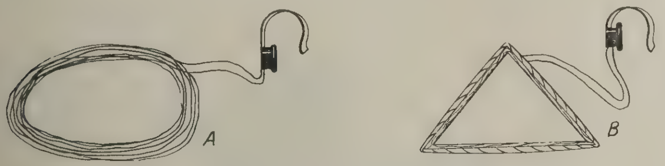
Ages pass and we find man so far developed that he has entered upon his inheritance. Some 2,500 years ago the old Greek philosopher, Thales, declared: "The Stone has a soul since it moves iron." He referred to loadstone which was found near Magnesia in Asia Minor. From the name of this ancient city we have derived the terms magnet and magnetism. Some three hundred years later mention is made of the fact that amber when rubbed would attract certain light articles. The Greek name for amber—electron—gave to this strange power the name of electricity. In these humble ways began the development of the great electrical industry.

PRACTICAL STUNTS

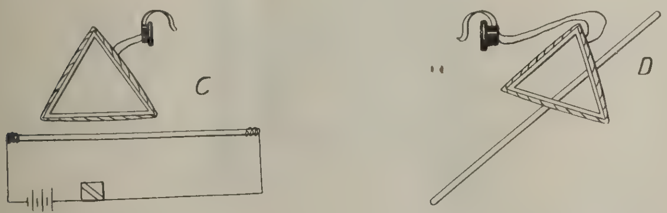
A Device for Locating Hidden Wires or Pipes

Occasionally some circumstance arises where it becomes desirable to know the exact path taken by some hidden electrical circuit or pipe line. It is quite possible to locate exactly not only wiring hidden behind the walls of a building but also pipes and wires that are located several feet underground. In the winter when it is necessary to dig up a pipe line, the ability to locate the buried pipe exactly may prove a tremendous labor and time saver.

The device used in detecting the location of pipes or wires consists simply of a coil of wire and a small telephone receiver. The type of receiver which is equipped with a head-band is most desirable as it leaves the hands free for the handling of the coil. In its simplest form, as shown at *A*, the coil is made of two or three pounds of insulated copper wire, held together in several places by pieces of string or tape. The range of the coil is really remarkable and the exact size of the wire and number of turns in it are not a primary importance except where it is desired to make a coil that is especially sensitive. A coil that is to be used to detect the presence of wires or piping which are located 10 or more feet away must necessarily be more sensitive than one where the wiring and the coil are separated but by a few inches.



A.—The Detecting Coil in its Simplest Form
B.—A Coil Wound On a Wood Triangular Frame



C.—The Correct Way to Hold the Coil with Reference to the Hidden Wire or Pipe
D.—If Coil is Held in This Way No Sound Will Be Heard in the Receiver

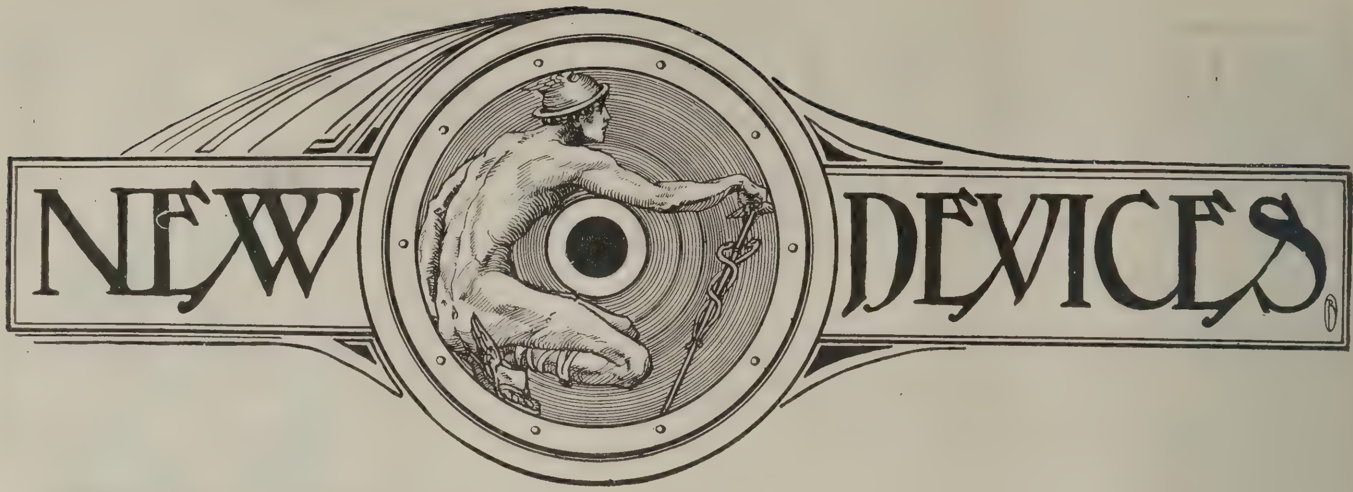
The ordinary telephone receiver, such as shown in the illustration, usually has a resistance of 75 ohms and it has been found by experiment that such a receiver will work most efficiently with a coil that has a resistance of 75 ohms also. This does not mean, of course, that only a very few turns of exceedingly fine wire having a high resistance should be used, but rather that many turns of wire approximately 22 P. & S. gage, be wound in the coil. This will make a very fair outfit. If a still more delicate outfit is required it is suggested that a receiver such as used in wireless telegraphy be used. Such a receiver has a resistance of something over a thousand ohms and the coil to which it is connected should consist of many turns of very fine wire so that its resistance will be equivalent to that of the receiver. An outfit so constructed is extremely sensitive. When much pains has been taken to perfect such a coil it is advisable to mount it upon a triangular wooden frame as shown at *B* and protect the entire winding with tape.

For the operation of locating an unseen wire or pipe, two or three cells of dry battery and a buzzer are required, together with sufficient wire to make the necessary connections. It is assumed that while the wire or pipe to be located is hidden from view for the greater part of its run, that at certain points, portions of it are exposed. At such places as these it is absolutely necessary to connect the buzzer and the battery circuit as shown at *C*.

Incidentally, this buzzer wire should be kept as far away from pipes or other wires as possible, and it also desirable to smother the sound of the buzzer so that it will not confuse the sounds in the receiver. Cloth of some kind will do this very effectually.

When the coil is placed in the position shown at *D* the lines of force of the magnetic field produced by the pulsating current of the buzzer will cut the wires of the coil and a sound will be distinctly heard in the receiver. The further away from the wire the coil is held the weaker will be the sound heard, and vice versa. It is very important that the coil be held parallel to the wire otherwise none of the magnetic field will cut the wires of the coil and no sound will be heard in the receiver. It is the knowledge of this fact that makes it possible to determine exactly the path of the hidden conductor. If the coil is held at right angles to the hidden conductor as shown at *D* no sound will be heard in the receiver at all.

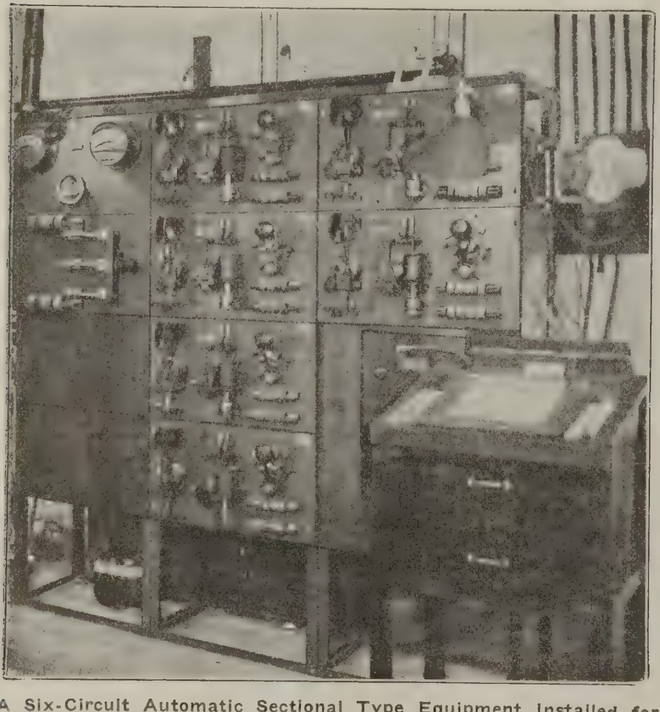
The outfit described above has been tried on many different occasions and in many different ways and has always given satisfaction.



NEW DEVICES

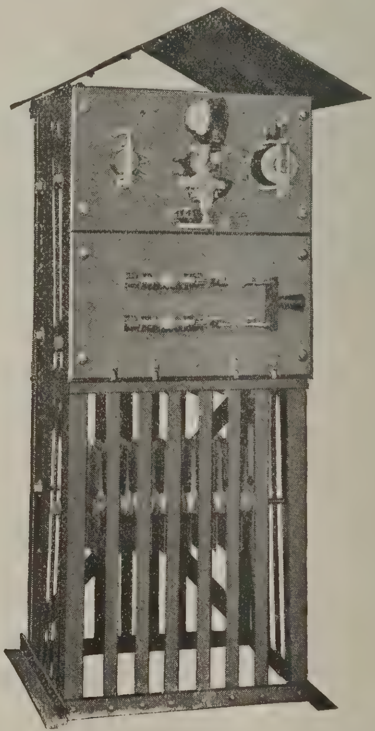
Automatic Charging Equipments

Two new automatic types of constant potential charging equipments have recently been placed on the market by the Cutler-Hammer Manufacturing Company, of Milwaukee and New York. One of these is a unit section to be mounted on the standard floor type frame for charging electric trucks, and the other a charging panel for mine locomotives equipped with Edison storage batteries.



A Six-Circuit Automatic Sectional Type Equipment Installed for Charging Trucks

The former consists of a slate panel carrying a single pole magnet switch, a solenoid relay, a manually operated mainline switch and two enclosed fuses. The panel is 15 in. high and 24 in. wide and is drilled for mounting on the standard floor type frame, which is capable of assembling from one to four sections. Each section is a complete charging unit in itself and may be assembled as needed. The charge is started by moving the main line switch, which is mounted on the right of the panel, to the "on" position, and inserting the charging plug in the battery receptacle. The main line switch may be left in the "on" position and the charge started by simply plugging into the battery. The panel automatically takes care of the charging rate so it is properly tapered, and an attendant's presence is not necessary until the completion of the charge which is terminated by moving the main switch to the "off" position, or by pulling out the charging plug. A charge can also be discontinued by the opening of a shunt switch circuit breaker controlled by an ampere hour meter on the vehicle.



The Automatic Charging Panel Used With Mine Locomotives

The solenoid relay which is set in motion by inserting the charging plug in the battery receptacle, is sufficiently retarded by a dash-pot to insure the plug being seated before the magnet switch closes to complete the circuit. The duplex meter mounted on a swinging bracket to the right of the frame section, gives simultaneous readings of the charging current and battery voltage when the main switch is moved to the third, or "meter reading" position. A spring automatically returns the switch from the "meter reading" to the "on" position. The charge is automatically given a tapering rate by means of a fixed resistance, which is designed with a proper capacity for the battery to be charged.

The new C-H charging panel, designed for the automatic charging of mine locomotives using Edison batteries, may be connected to a 250 to 275-volt direct current circuit. It consists of a slate panel supported by a floor type mounting frame having the charging resistance self-contained. A sheet metal roof protects the charging resistance and the magnetic switches on the panel from the mine drippings. The switch equipment on the front of the panel consists of a main line knife switch with renewable fuses, magnetic main line contactor, voltage relay and shunt trip relay.

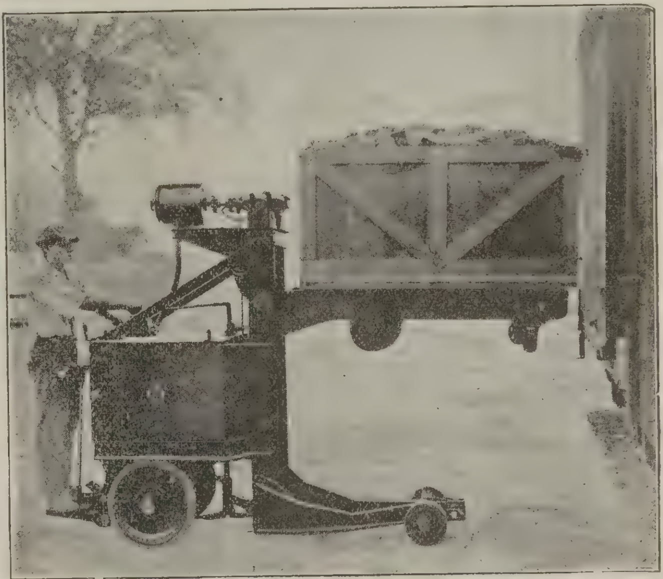
The main line contactor, which connects and disconnects the battery from the line, is controlled through the voltage relay and the shunt trip relay. The former prevents it from closing unless the line voltage is of sufficient value for charging, and causes it to open if the power fails or the line voltage drops below a predetermined value, thereby guarding against the batteries discharging back into the line. On restoration of the power after a power failure, the main line contactor again closes, and the charge is continued. The shunt trip relay is connected to the ampere-hour meter on the locomotive and when the battery is fully charged the ampere hour meter will energize the relay which in turn causes the main line contactor to open and disconnects the battery from the line. This relay also opens the contactor should the line voltage become too high. Thus the voltage and shunt trip relays permit charging only when normal conditions prevail on the line, that is, the supply voltage must lie between the limits for which the two relays are set.

High-Lift Elevating Platform Truck

An industrial truck, which with its own power elevates the loads to sufficient heights to put the material in box cars or stock rooms without rehandling, has been developed by the Lakewood Engineering Company, Cleveland, Ohio. This new truck performs the functions of a tiering machine as well as those of a load-carrying storage battery truck, and is called the Tier-Lift truck. It can elevate a two-ton load to a maximum height of 76 in. or to any intermediate height.

It has always been customary to transport material by means of hand trucks or some kind of power-driven truck which acted as a carrier only, but with this method men are required to transfer and lift the loads, and even when cranes are available considerable manual labor is required to handle the material. The use of the Tier-Lift truck, however, releases the cranes from considerable work, gives a more flexible distribution system and reduces the waste of man-power. The height to which material can be piled economically is greatly increased and the storage capacity of a given floor doubled or tripled by the high lifting feature. The storing of material on skids to prevent rehandling in the storeroom is also made practical. Where the material is such that it can bear the weight of loads above, the loaded platforms can be piled on top of each other. The labor cost is thus reduced, material can be handled more quickly and storage capacity of the floor space is greatly increased. With the arrangement shown any loaded platform in the racks may be removed without disturbing the other loads, thus giving flexibility in the storeroon.

It is claimed that the four-wheel steer allows the truck to turn in a circle 92 in. in radius, thus permitting operation in narrow aisles or congested parts of the plants and giving easy entrance into box cars, small storerooms, etc. The same form of drive is used in this truck as in the Lakewood tractor. There are three speeds forward and three speeds reverse. The controller handle is conveniently located for operation for travel in either direction. The lifting mechanism is operated by means of a specially designed controller, with one speed in either direction. The lifting is done through two steel worm screws, a separate motor being used to supply the power.



Tier-Lift Elevating Truck Made by the Lakewood Engineering Company

The load platform is carried by a cantilever type support and the load is balanced over the carrying wheels. Ballbearings are used throughout, and by a special design the friction losses in elevating and lowering the load platform are greatly reduced. It is claimed that the truck is easy to operate, and its use will effect a considerable saving of both time and labor.

Edison Base Cleat Receptacle

A standard Edison base cleat receptacle has been placed on the market by, Kirkman Engineering Corporation, 237 Lafayette Street, New York City. The receptacle is constructed of highly finished, heavy white porcelain, with exposed terminals. Both the bottom and side contacts are made of heavy gage metal of a current carrying capacity that permits the receptacle to be used for heavy duty. The receptacle is designed for use in open wiring and cleat jobs and will carry 660 watts when installed on 250-volt circuits.

General News Section

Thompson Electric Co., manufacturer of the Thompson safety disconnecting hangers, has moved from 5606 Euclid avenue, Cleveland, Ohio, to 226 St. Clair avenue, East, that city.

Employees of the Pennsylvania Railroad belonging to the National Guard may have two weeks' leave of absence without loss of pay or of annual vacation privilege, when required to take time for field training. This is the substance of a resolution which has been adopted by the directors of the road.

Twenty-four Thousand Miles of copper wire strung in six months.—Since August, 1919, the Mackay Companies have strung almost 24,000 miles, or 5,000,000 pounds, of new copper wire between the commercial centers of the United States. Though this has been brought about by expansion in telegraph business, the wires are available for long-distance telephone service.

Cutler-Hammer Mfg. Co., Milwaukee, Wis., has acquired the five-story building at 317-323 North Michigan avenue, Chicago, for a period of ten years. The property fronts 80 feet on Michigan avenue with a depth of 63½ feet, and has a 20-foot alley on the south and a 40-foot alley on the east side, so that each floor will have 5,000 square feet of floor space with light on three sides. The company will occupy the first two office floors and basement and will sublease the stores and balance of the building.

The George Cutter Company of South Bend, Indiana announces the acquisition of a financial interest in their company by the Westinghouse Electric & Manufacturing Company. The management and the commercial policies will remain unchanged, but advantage will be taken of the Westinghouse engineering and other facilities to expand the Cutter company's activities and develop its lines to enable it to more effectively serve its customers and the industry. The Westinghouse company will operate as sole distributors for the Cutter company's products.

A strike of clerks on the Norfolk & Western, on March 22, blocked freight office work at Norfolk and also at some other points, to the extent that a partial embargo on freight shipments was placed at Norfolk on March 26. The strikers' grievance appears to have been local and to have been disapproved by general officers of their union; but the strike was still on at the time of going to press; and the shopmen in the large shops of the road at Roanoke, Va., struck in sympathy with the clerks, on the 31st. The shop strikers claim that 5,000 men were out.

An extensive plot to defraud the Railroad Administration of thousands of dollars through the circulation and sale of counterfeit passes was recently revealed with the arrest of a passenger on one of the trans-continental trains of the Atchison, Topeka & Santa Fe, as the train entered Chicago. Four others were arrested in connection with the plot at the same time, three at Los Angeles and one, a former brakeman and the originator of the plot, at Portland, Ore. The plan for the circulation and sale of counterfeit passes is said to have originated last November, since which time it is said that hundreds have been sold and used, most of them for trans-continental trips.

An attempt to wreck Chicago, Burlington & Quincy westbound train No. 5 was made on the evening of March 26, soon after the train left Chicago, carrying an express shipment valued at $150,000. Acting upon a tip that a hold-up was contemplated, the train was switched to the eastbound track, near Neponset, Ill., and it safely passed a large pile of ties placed on the westbound track. The suspicions of farmers living in the vicinity of Neponset were aroused earlier in the day by inquiries made by strangers and the appearance, on the evening of the attempted wreck, of four unknown men. The farmers later notified police officers, who in turn notified the road's special police. Seach is now being made for the strangers.

Eighteen tests were recently conducted by the road foremen of engines on the Baltimore & Ohio, Western Lines, for the purpose of determining how much coal is required to stop and start a slow freight train. The tests, which were run on an average of 7½ miles each, one trip without a stop and one trip including a full stop, indicated that the excess coal consumed per stop was 328 lb. When no stop was made the average coal consumption was 1,204 lb., while an increase of approximately 21 per cent or 1,532 lb. was consumed when making a stop. J. B. Carothers, assistant to the federal manager, in a statement recently issued concerning the tests, states that unnecessary stops are caused principally by signal failures, failure of an operator to give a clear signal promptly, unnecessary slow orders, unnecessary flagging by the maintenance department, indifferent train dispatching and poor train inspection.

Cheap Wireless Talk Across Ocean

Signor Marconi prophesies that in the immediate future conversation between Great Britain and the United States will be carried on by wireless telephones and that the price will not be more than 14 cents for one minute.

The great inventor said that he spoke direct to Canada from London, and he added:

"It is only a matter of time when we shall be able to talk to New York from London. Already we have carried out many successful experiments between London and the Continent, and we hope that we shall be able soon to announce the installation of a world-wide wireless telephone system in all countries interested. Our plans are developing rapidly."

Transoceanic conversations will be carried on through an ordinary telephone, the exchange being connected with the wireless stations at the receiving end, and the same methods will be followed.

Signor Marconi already has applied for permission to erect a station in Norway to demonstrate his ability to talk across large expanses of water.—*Telephone Engineer.*

Wireless Telephone Experiments on the New York Central

Major General George O. Squier, chief signal officer of the United States Army, well-known electrical inventor, has been making experiments on the Harlem and Putnam divisions of the New York Central with a radio telephone, in which the direction of the waves is guided by the telegraph or telephone wires strung along the line of railroad on poles. By utilizing this aid of the wires he is able to send a number of communications along the line simultaneously, and he speaks to and from moving train. An account, in considerable detail, is given in the New York Central Magazine for February.

General Squier calls his system "wired wireless" and successful experiments were made between Elmsford, N. Y., and Millerton, 78 miles. The wire circuit which was made use of was at the same time being used for sending Morse messages (on two wires) and long distance telephone conversations.

Major General Squier began his researches ten years ago and received his basic patent January 3, 1911. He has renounced his rights in the invention, dedicating it to free use by the public. Tests have been made for a number of years, but the most important ones were those held early last month on the New York Central's long distance telephone wires. The tests are believed to have proved the feasibility of superimposing a number of additional telephone circuits on one pair of wires by using a different frequency of current. The wired wireless talk in this test was carried on for one hour without interruption and the transmission was excellent. The tests were made from a government experimental car stationed at Millerton, under the direction of Lieut. R. D. Duncan.

"Wired wireless" is a system of guiding radio currents by means of a wire. The currents do not travel through the wire, but travel alongside it; it guides them to their destination. The wave currents stay close to the wire, thus insuring not only reliability, but also secrecy. Thus the high frequency current which General Squier uses passes through the ether as do radio waves, with the difference that instead of being diffused it travels in a path of which the wire is the center. The apparatus is the ground set of the standard ground aeroplane radio telephone equipment. It consists of two three-electrode vacuum tubes of the transmitting type, a powerful oscillator and a modulator, a connecting circuit and a two-stage audio frequency amplifier.

General Squier obtains his results by the use of electro magnetic waves or oscillation of high frequency. In his investigations he found that there was a range of frequencies which had hitherto been ignored and this range he utilized. The oscillations in this range are so delicate they cannot be detected by the unassisted ear and they have to be strengthened to bring them within the perception of our sensory apparatus.

General Squier has produced frequencies which reached 600,000 a second. These currents do no harm to ordinary telephone apparatus. General Squier in effect has taken the vibrations of wireless and used them on the telephone. He says:

"Since a plurality of high frequency waves of different frequencies can be impressed upon the same line and since these may be selectively separated from each other by suitably tuned circuits, it is obvious that multiplex telephony may be accomplished. These high frequency waves may exist on the same line with ordinary battery telephone circuits without in any way affecting them, and thus this system of multiplex telephony may be applied to the usual telephonic circuits without the presence of harmful effects, such as cross talk or other disturbances."

PERSONALS

Edward Wray

Edward Wray has associated himself with *Railway Materials* as managing editor, with headquarters in Chicago. Mr. Wray was formerly managing editor and publisher of the *Railway Electrical Engineer* from its first issue in 1909 to 1916, when the magazine was purchased by the Simmons - Boardman Publishing Company, publishers of the *Railway Age*. Following the sale of the *Railway Electrical Engineer,* Mr. Wray continued his connection with the magazine as business manager, and later became associated with the Sangamo Electrical Company, Springfield, Ill., as assistant general manager. In this capacity he had charge of the production, costs and stores departments of the company and the advertising and welfare departments. Mr. Wray received his education at the University of Wisconsin, graduating in 1905. He received the degree of electrical engineer in 1906, following a year of special work devoted exclusively to the investigation of all of the various systems of lighting steam railroad cars by electricity. In carrying out this work Mr. Wray had the assistance of 10 electrical students of the senior class at the university. Mr. Wray is a member of the American Institute of Electrical Engineers, associated member of the Railway Storekeepers Association and of the Association of Railway Electrical Engineers, and has been treasurer of the Railway Electrical Supply Manufacturers' Association since its organization in 1909. *Railway Materials,* the paper of which Mr. Wray is now managing editor, until recently was known as the *Railway Storekeeper.*

It is published by the former Railway Storekeepers Association, now known as Section VI, Purchases and Stores of the American Railroad Association.

Arthur Strobl has entered the employ of the St. Louis-San Francisco Railroad as electrician, first class, located at St. Louis, Mo.

Frank Nelson, electrician on the Chesapeake & Ohio at Richmond, Va., has been transferred to Newport News, in the same capacity, to succeed **Clyde H. Campbell** who has left that company.

E. C. Conners, of the construction department of the Alaskan Engineering Commission, has been appointed assistant superintendent of construction in the telegraph and telephone department, with headquarters at Anchorage, Alaska.

Clyde H. Campbell, electrician on the Chesapeake & Ohio at Newport News, Va., has left that company to become foreman electrician on the Virginian Railway and is now gang foreman in charge of automatic control switchboards and electrical maintenance of the coal pier at Sewells Point, Norfolk, Va.

W. Jerry Stanton has accepted a position with the Ohio Brass Company. He has been in the electrical industry for twenty years, starting with the General Electric Company. Mr. Stanton spent eighteen years in the testing, engineering and sales departmnet of that company. He has also been connected with the Railway Improvement Company and the National Railway Appliance Company.

A. L. Wilkinson, who was connected with the **Ohio Brass Company** for twenty-six years, the last year of that time as vice-president, has persuaded the directors to accept his resignation. For some time he has felt the need of a complete rest for the benefit of his health and he desired freedom from all responsibility. Mr. Wilkinson began as a salesman and was promoted successively to general sales manager, secretary and vice-president.

The Westinghouse Electric & Manufacturing Company announces the appointment of **Messrs. W. S. Rugg,** manager of the railway and marine departments, and **Charles Robbins,** assistant sales manager, as assistants to vice-president.

Mr. Rugg was born at Broadhead, Michigan, and is a graduate of Cornell university. Soon after his connection with the Westinghouse organization he was transferred from Pittsburgh to Chicago and in 1901 he was transferred to New York as special engineer. Eight years later he was made manager of that office. In 1917 he was recalled to East Pittsburgh to take charge of the railway department where, in 1918, he was also made manager of the newly created marine department.

Mr. Robbins began his connection with the company in 1899 at its New York office. He was transferred in 1906 to the main offices at East Pittsburgh as assistant to the manager of the industrial and power departments. He retained this position until his appointment to the position of manager of the industrial sales department in 1910. In August, 1915, he was made assistant sales manager, from which he was promoted to his present position.

TRADE PUBLICATIONS

"Trumbull Cheer" is once more with us. This time it is the March number and the story of "A Bean or A Walnut" on page 8, is exceptionally good.

The Thompson-Levering Company, Philadelphia, Pa., has issued a pamphlet describing the Vawter indicating bond tester. Emphasis is laid upon the statement that the instrument is particularly adapted to use in the field.

The Westinghouse Air Brake Company, 165 Broadway, New York, has issued a descriptive catalogue No. 2021 which describes its recently standardized UC electro-pneumatic brake equipment for steam road passenger trains.

The Ohio Brass Company, Mansfield, Ohio, is distributing its price list No. 207 applying to catalogues 201, 202, 202-A, 203 and 205, which deal exclusively with the Crouse-Hinds imperial headlights. This price list is effective February 15, 1920.

Templeton-Kenly & Co., Ltd., Chicago, has just issued its bulletin No. 820 describing and illustrating its line of Simplex track and ballast jacks. On one of the pages a reproduction of a blueprint is shown in which the various parts of the jack are depicted. A large photograph is also included showing the application of the jack to the track.

General Electric Company, Schenectady, N. Y., is distributing its bulletin No. 48029, illustrating and describing the reversing drive for planers, etc. For this type of service the motor known as the RF type has been designed. The bulletin shows a large number of photographs, both of the various motor parts and the different types of panels for use in operating the motor.

The Cutler-Hammer Manufacturing Company of Milwaukee, Wis., and New York, is distributing a small folder describing C-H electric space heaters, known as publication 494. This folder is a 6-page envelope size, supplied to various electrical supply houses who are now disposing of this line of C-H industrial heating apparatus. One of the illustrations shows the space heater with a 2-ft. rule held alongside to thoroughly illustrate the fact that this heater is 2 ft. long. It is referred to in the folder as "Two feet of electrical heat."

The Anaconda Copper Mining Company, 42 Broadway, New York, has issued a catalogue with the title "Copper—From Mine to Finished Product." It is a brief description of the smelting, refining and rolling of copper, the electrolytic refining of zinc and the refining of lead as practised in some of the plants of the Anaconda Copper Mining Company. There are many illustrations of the company's plants and processes, panoramic views of the Butte copper country and much interesting and valuable metallurgical information.

The Central Electric Company, Chicago, is distributing its bulletin No. 75, entitled "The Maxolite." The first few pages of the bulletin illustrate the various types of the Maxolite reflectors. These illustrations are printed in blue to more nearly represent the actual apparatus. The Maxolite cut-out hanger is also illustrated in detail and by the aid of the phantom drawings the various parts are clearly shown. Two other lighting fixtures are also illustrated in the bulletin, namely, the Duplexalite and the Alexalite.

Railway Electrical Engineer

Volume 11 May, 1920 Number 5

NOTICE

Notice is hereby given that the services of Clayton L. Smythe as circulation manager of this publication have been discontinued by us and that he does not now in any way represent this company or any of its publications.

A PAPER SHORTAGE

Owing to the present scarcity of paper, it has become necessary for us to discontinue all subscriptions promptly at expiration. In the past, it has been our custom and our pleasure to allow subscribers two or three months in which to renew. We would suggest that our readers renew promptly upon receipt of notice of the expiration of their subscriptions.

Unfortunately, we will not be able to print any more copies than the number necessary to supply our regular subscribers and if your name is removed from the list it is doubtful whether we will be able to supply back numbers if you desire them at a later date.

We are confident that our readers will appreciate the necessity of a stand of this kind and we know that we will receive their hearty co-operation.

THE ATLANTIC CITY CONVENTIONS

The convention season at Atlantic City this June should not fail to exceed last year's program both in the number of reports presented and in the amount of floor space used by the exhibitors. In addition to the meeting of the American Railroad Association, Section III. Mechanical (formerly the Master Mechanics' Association and the Master Car Builders' Association), Section VI., Purchases and Stores will also hold its annual convention. The extent of the exhibits on Young's Million Dollar Pier will greatly exceed any former convention exhibit, for even the balcony in the main hall has been turned over to exhibitors.

The Association of Railway Electrical Engineers will hold its semi-annual convention at Hotel Dennis on Monday, June 14. In keeping with the established custom the entire program will be confined to a single day which will be taken up with the presentation and discussion of progress reports. The following subjects are included in this year's list: Electric welding, train lighting equipment and practice, railway stationary power plants, electric headlights, electrification and electrical repair shop facilities.

The convention session is scheduled to commence at 9 a. m., and it is most desirable that it should do so. Inasmuch, as the entire program is presented in one day it is of utmost importance to begin both morning and afternoon sessions promptly on time. This is the only way in which the greatest benefit can be had from the meetings. When an hour is lost in the morning and the greater part of another hour again wasted in beginning the afternoon session, the already short day is curtailed to such an extent that the end of the program is rushed and the latter reports receive but scant consideration. This can be and should be remedied by co-operation on the part of the members. Get out to the meetings at the scheduled time. Get on your feet and talk if you have anything to say. That's the way to make the convention a success.

THE STRIKERS AND THE PUBLIC

The so-called "outlaw" strike among certain railroad employees last month, presented a number of interesting phases that are particularly worthy of consideration. In the first place the strike itself was marked by hasty action of a radical element and from its inception to its conclusion the strikers were at odds with the four recognized brotherhoods. This from the very beginning spelled an unsuccessful termination from the outlaw's viewpoint, for not only were the strikers confronted with the measures taken by the companies to break the strike, but they had to contend with the opposition of many of their fellow workmen who remained at work. The whole movement was apparently without recognized leaders or organized followers. "Sporadic" is the word that seems best to describe it.

The most significant development which occurred soon after the tie-up of passenger service became serious in the metropolitan district, was the determined effort on the part of the traveling public to reduce their inconvenience to a minimum. This was evidenced by large numbers of individuals voluntarily offering their services in the capacity of temporary train crews. The people were bitterly opposed to the inconveniences with which they were obliged to contend and it was not at all surprising that volunteers manned many trains. Moreover, it is quite obvious that the fact that the strikers were not acting with the sanction of the four recognized brotherhoods had little or nothing to do with the matter so far as the public was concerned. The expressions of dissatisfaction with the trouble and the delay caused to thousands of commuters would have been just as forcefully demonstrated had the strike been called by any of the four brotherhoods themselves.

Underlying the entire episode there is unquestionably a strong feeling on the part of the inconvenienced public that such conditions should not be permitted to exist. The traveling public suffered a really great economical loss, while the loss of perishable food stuff was tremendous. Why should any group of men be in position to paralyze transportation to the extent that hundreds of thousands of persons are caused great inconvenience? From the standpoint of the public there is no reasonable answer to the question and it is highly probable that should a repetition of the strike occur more drastic measures than ever would be taken to keep the trains moving.

A WELDING CONTROVERSY

The art of electric arc welding is still in a stage of development and users of electric welding can profit by the experience of welders in other shops. The first annual meeting of the American Welding Society, held in New York on April 22, brought out the fact that there is yet much to be done in the matter of assuring a good weld and in eliminating locked-up stresses in long welds. The necessity for users and manufacturers to exchange ideas was emphasized and the thought was expressed that more can be done during the coming year in controlling the conditions under which the work is done than in developing a method for testing the weld after it is made.

Readers of the *Railway Electrical Engineer* who have followed the series of articles on welding by E. Wanamaker and H. R. Pennington will be interested in reading the criticism by J. Churchward which is published elsewhere in this issue. An article in the March issue on the practical side of electric welding by John C. Weis has brought out several new and interesting angles by J. M. Riker. The more discussion that can be aroused on this important subject the better it will be for the men engaged in the work. Even though arc welding has come into such extensive use there are still many unknown facts in connection with it as regards both theory and application. By investigating the properties of the electric arc as used in welding, new discoveries are likely to be made, and the more persons interested in the work, the larger this number of discoveries is likely to be. In order that the general knowledge of the welding art may be increased, that each investigator may know what his fellows have found out, it is necessary to give the subject an abundance of publicity. Your experience can be used to advantage by other welders, and the *Railway Electrical Engineer* will welcome an expression of your opinion. What can you do with electric welding? What practices ought to be discontinued? How can you assure the success of a weld?

LETTERS TO THE EDITOR

Truck Hung vs. Body Hung Generators

To The Editor:

In considering the subject of truck hung and body hung generators and the merits of each from the standpoint of satisfactory driving qualities, it occurs to me that a profitable discussion might be started in your paper on this subject.

The tendency is largely toward body hung, but it is still a question as to whether the advantages of such mounting may not be outweighed by failure to drive as well in bad weather as the truck hung type.

Last winter was a severe test for drive and it would be interesting to hear from various maintenance men, as well as from engineers, regarding the results obtained, with comparisons of performance. It is possible that many of the departments have no records available as yet, but their judgment on the matter would be of interest and any discussion started would be certain to react to the benefit of the men handling the equipments, especially if they are obtaining better results with some suspensions other than the ones furnished by the various manufacturers.

George W. Wall, Foreman Electrician,
D., L. & W. R. R., Hoboken, N. J.

[Hundreds of car lighting men will read this letter. It touches upon a subject about which each one of them holds very definite opinions; opinions based upon personal experience with both types of suspension. What has been your experience? Which do you feel is the better method? Let us have an expression of your opinion in a letter to the Editor so that we may give it publicity in these columns for the benefit of all car lighting men.—Editor.]

NEW BOOKS

Inventions, Their Purchase and Sale. **By William E. Baff, 230 pages, 5 in. by 7½ in., bound in cloth. Published by D. Van Nostrand, New York.**

This book is written by a patent attorney who is familiar with the steps by which many inventors have turned their patents to good account and contains many commonsense suggestions on how to make the most out of an invention after the patent has been obtained. It is essentially a business man's book on the marketing of inventions and does not deal directly with inventions in their inception and handling through the patent office.

Invention has played an important part in railroad development and patents developed in railway practice are usually taken in hand by some carrier for the privilege of using the device if it proves successful in operation. If the inventor obtains a broad patent upon a meritorious device he is usually successful in placing it in the hands of an established supply house and does not find it necessary to engage in the business of marketing his invention in order to realize a profit from it. However, no inventor can afford to overlook the business viewpoint. No matter how ingenious his invention may be, it must be something upon which business men can make a profit. This book will recommend itself to any inventor who is anxious to know what is required of a patent to make it successful.

Minimum Full-Load Speed for Axle Generators

Any Universal Equipment Must Be a Compromise Between the Extreme Conditions Encountered

By J. Lester Woodbridge and F. G. Beetem

THE question of the most economical minimum full-load speed for which axle driven generators should be designed has aroused considerable interest of late, and given rise to more or less discussion which does not appear to have resulted in any very generally accepted conclusions. Indeed, the problem involves so many variable factors, that the results obtained will naturally vary widely, depending upon the conditions assumed. The following analysis may, however, throw some additional light on the question under discussion and be of material assistance in applying general principles to any concrete case.

Before taking up the analysis in detail, a simple statement of the problem will be helpful. Assume that an axle driven generator is in service on a given schedule involving a certain number of stops and more or less variation in speed between stops. The generator is designed to cut in at say 18 miles per hour and to give its full rated output at 25 miles per hour. Now it is perfectly possible to design another machine of substantially the same mass and cost which, while having a greater capacity, will not cut in nor load up until higher speeds are attained, but will give a greater output at the higher speeds, and this increase in output at higher speeds may or may not compensate for the loss at lower speeds. On the other hand, it is also possible to design a machine of the same mass and cost, but of smaller capacity, which will cut in and load up at lower speeds, and the gain at lower speeds may or may not compensate for the lesser output at higher speeds. The problem is, then, to determine, for a given mass and cost, what design, in respect to cut-in and full load speed, will give the maximum output for any given train schedule. The schedule conditions of course constitute a vital factor in the problem. If the train, at starting, comes up immediately to a speed of 50 miles per hour and always runs at that speed while in motion, a machine designed to develop full load at not less than 50 M.P.H. will give the maximum output for a given mass and cost. If, however, the train speed is always 20 M.P.H. while in motion, the machine should be designed to develop full load at that speed. If all schedules were as simple as these two illustrations, there would obviously be nothing to the problem. However, these two illustrations serve to demonstrate one point which is often lost sight of, namely, that the length and frequency of stops have nothing to do with the problem, and any solution based on *average* schedule speeds *including stops* is liable to serious error.

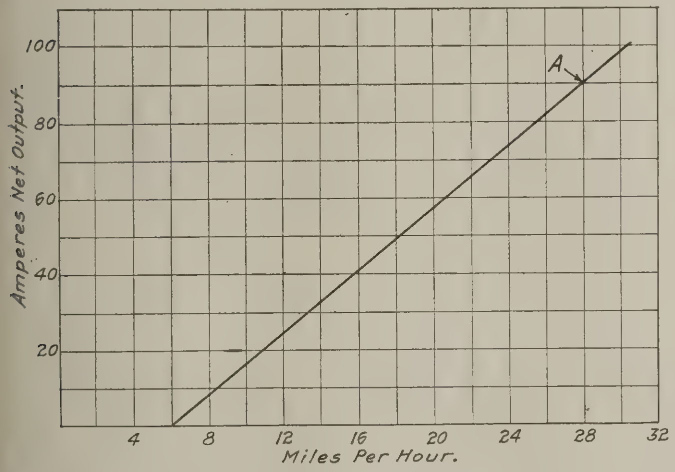


Fig. 1.—Curve Showing Relation Between Net Rated Output and Minimum Full Load Speed

Heretofore, the great majority of axle driven generators have been applied to comparatively high speed trains, and nothing was to be gained by designing for slow speed work; but the recent tendency to extend this method of lighting to branch line and local service in schedules involving widely varying speeds has added materially to the complication as well as the importance of the problem.

This analysis may conveniently be divided into three parts, (1) Generator Design and Performance, (2) Train Schedules, and (3) the combination of (1) and (2) for the solution of a given case. We will take these up in the order mentioned.

(1) Generator Design and Performance

As stated above, for a given mass and cost, a wide range of generator design is possible, the rated capacity increasing with increase in minimum full load speed.* This variation will not be in direct proportion for two reasons; first, because the variations in design under consideration are practically limited to changes in the number and cross section of armature conductors, and as the size of conductor is increased and the number per slot decreased, the space factor, or proportion of conductor to insulation increases, so that the capacity increases more rapidly than the minimum full load speed; and second, because a certain amount of the developed energy must be consumed in the controlling devices, and this amount is practically constant.

In Fig. 1 is given a curve showing the relation between the net rated output and the minimum full load speed. The point marked "A" on this curve corresponds to a machine designed to give a *net* output of 90 amperes at 40 volts at a train speed of 28 M.P.H., with a pulley ratio of 17 to 8. Other points on the curve are determined by varying the number and section of armature conductors, holding the field excitation constant, and varying the speed to maintain the same voltage. The capacity will then be determined at each point from the section of armature conductor. It will be noted that as the speed and capacity are reduced, a speed is finally reached where the *net* output is zero, all the energy developed being consumed in field excitation and in the regulating devices:

---

*In this analysis the pulley ratio is assumed constant. The question of pulley ratio is another problem, but need not be injected here.

(2) Train Schedules:

For the purpose of this discussion, a number of speed time curves, covering a wide range of operating conditions in branch line service have been studied. These curves were obtained for the express purpose of discussing this problem and include runs which were considered the most difficult to handle as well as others representing more nearly average conditions and still others showing comparatively high train speeds. From these curves three were selected, including the most difficult run, and a typical run from each of the other two classes. These are shown respectively in Figs. 2, 3, and 4.

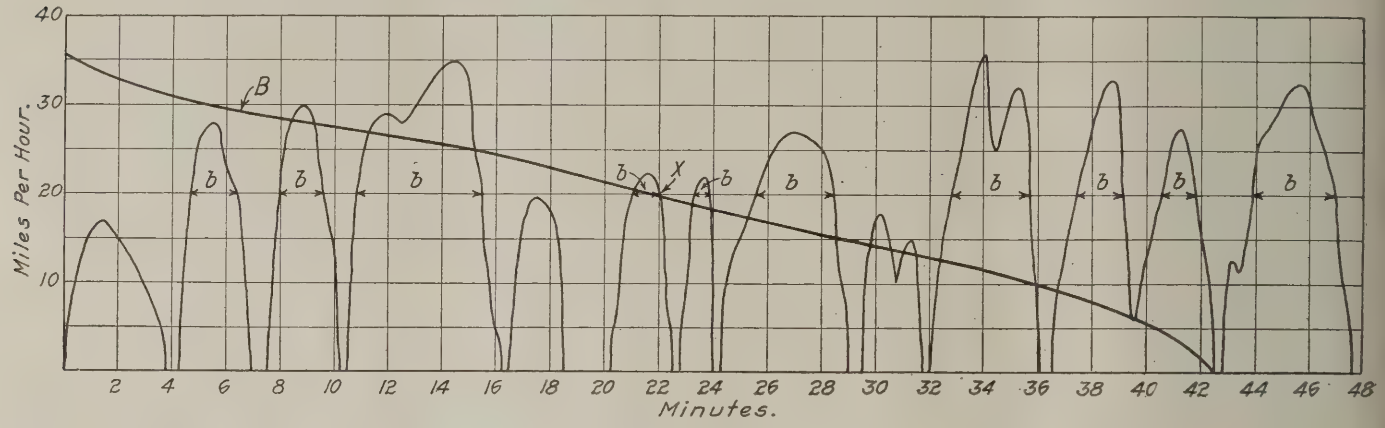


Fig. 2.—Showing the Relation of the "Run Characteristic" to the Speed Time Curve for a Difficult Run

On each of these figures has been plotted a sloping line "B," obtained by determining from the speed time curve the total time during which the train was running at or above a certain speed and plotting this speed and time to the same vertical and horizontal scale as the speed time curve. Thus in Fig. 2, the point "X" on the line "B," corresponding to 20 M.P.H., was obtained by passing a horizontal line at a height of 20 M.P.H., and adding together all the intercepts, *b*, giving a total of 22 minutes, which is taken as the abscissa of "X," indicating that the train was running at or above 20 M.P.H. for a total of 22 minutes during the run. The line "B" may be called the "Run Characteristic," and shows the total time of operating at or above any given speed. In Fig. 5 the three Run Characteristics shown in Figs. 2, 3 and 4 have been replotted to a horizontal scale of hours instead of minutes.

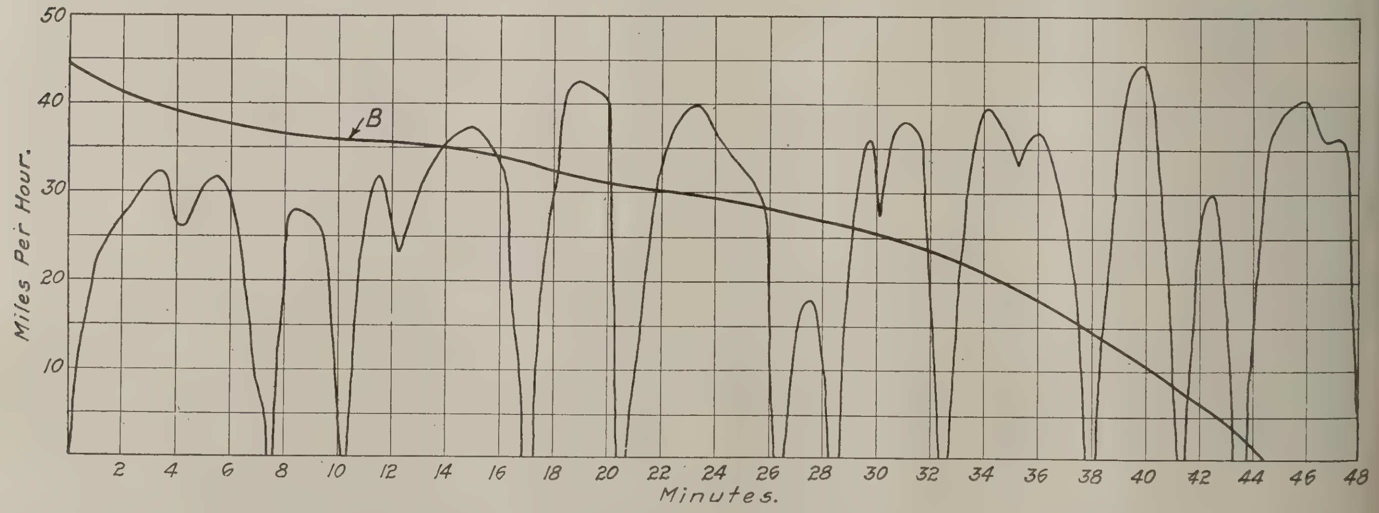


Fig. 3.—Speed Time Curve and "Run Characteristic" Representing More Nearly Average Conditions

(3) The Solution:

The solution of the problem before us is obtained by combining the data derived from (1) and (2). Assume that each of the generators corresponding to the various points on the curve in Fig. 1 is applied to the three runs represented in Fig. 5, and determine the total output in ampere hours developed by each of these machines, plotting these outputs to a base line of speeds in M.P.H., the speed in each case being the minimum full load speed of the particular machine under consideration as taken from the curve in Fig. 1; the output being computed by multiplying the rated capacity of this machine by the total time corresponding to the same speed in the "Run Characteristic." In this way the three curves I, II, and III, shown in Fig. 6, have been plotted, corresponding respectively to the three runs represented in Figs. 2, 3 and 4. For example, point *y* on curve I, whose abscissa is 20 on the horizontal scale and whose ordinate is 20.8 on the vertical scale, indicates that a machine designed for a minimum full load speed of 20 M.P.H. with a rated capacity of 57½ amperes (net) would give an output of 20.8 ampere hours during the run represented in Fig. 2. This result is obtained by multiplying the capacity of the machine (57½ amperes as derived from the curve in Fig. 1) by the total time (0.36 hours) that it is running above its full load speed of 20 M.P.H. as shown on the "Run Characteristic" (line *a*, Fig. 5). Similarly, various other points corresponding to the different machine capacities represented in Fig. 1 have been plotted for each of the three runs and connected by the curves I, II, and III, respectively, in Fig. 6.

The principal conclusion to be drawn from these curves is obvious. Curve I shows that for the most difficult run, represented in Fig. 2, a machine designed for a minimum full load speed of 22 M.P.H. will give the *maximum output* (for a given mass and cost), but very little difference in output is shown over a range from 20 M.P.H. to 23 M.P.H. For the typical medium speed run represented in Fig. 3, the maximum output is obtained with a machine designed for a minimum full load speed of 26 M.P.H., and for the high speed run represented in Fig. 4, the maximum output is obtained with a machine designed for a minimum full load speed of over 37 M.P.H.

In the above analysis, it has been assumed that at all speeds below minimum full load speed the output of the generator is zero. This is not strictly true, but in order to determine the effect of this assumption, another series of computations were made, taking into account the output at lower speeds. In these computations it was assumed that at 75 per cent of minimum full load speed the machine would just begin to develop useful output, and that this output would increase directly with increase of speed, up to full load speed. The difference in running time on the run characteristic between minimum full load speed and 75 per cent of this speed multiplied by half the full load output in amperes (the *average* output during this time), is the additional output due to this method of computation, which, added to the results shown on curve I, gives the dotted line Ia. The effect of this on the speed for maximum output is very slight, but in the direction of increase.

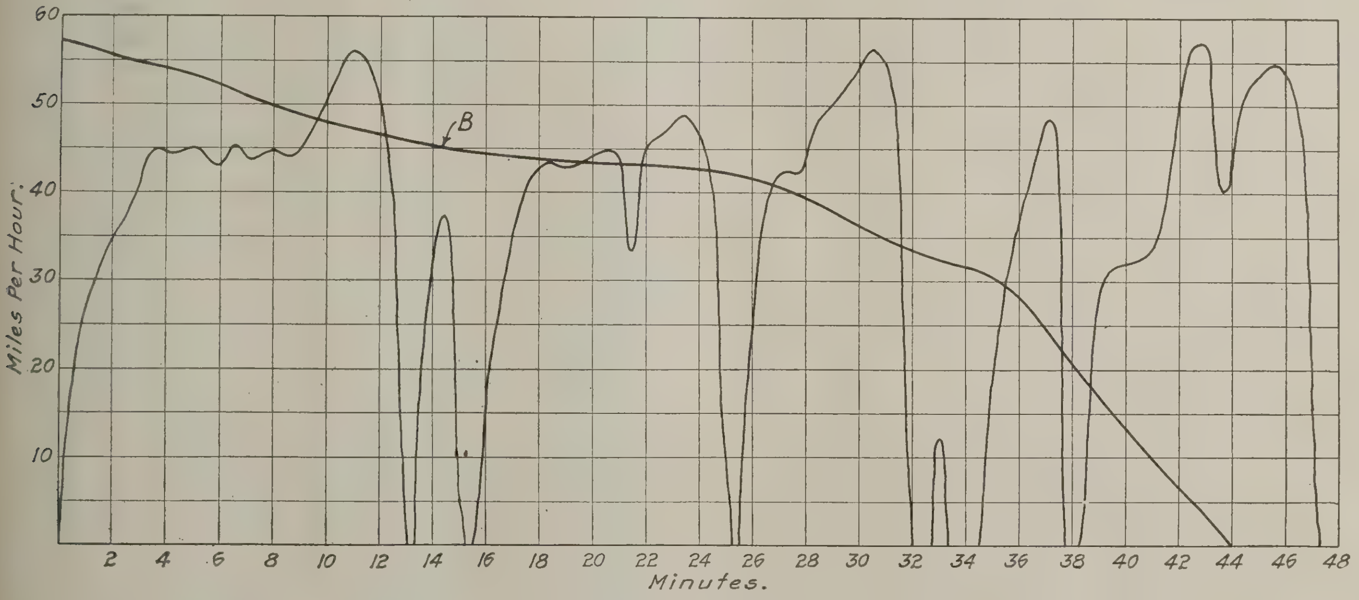


Fig. 4—Speed Time Curve and "Run Characteristics" Representing Comparatively High Train Speeds

It is evident from the results of the above analysis that the design of generator best adapted to the slow speed run is not the best for the higher speed runs, and vice-versa. Nor is it true, as has sometimes been stated, that a machine designed for the most difficult run will necessarily take care of a higher speed run. For, if we assume the same route covered at higher train speed, the time that the generator is in operation will be reduced and the ampere hour output reduced in proportion, whereas the current consumed by the lamps would not be reduced to the same extent, since the stops and layovers would remain the same. However, the higher train speeds are generally found on runs with fewer stops, and in that case the machine designed for maximum output on the slow speed run would handle the high speed run, although not designed to give the *maximum* output that could be obtained from the same material in a machine especially designed for higher full load speed.

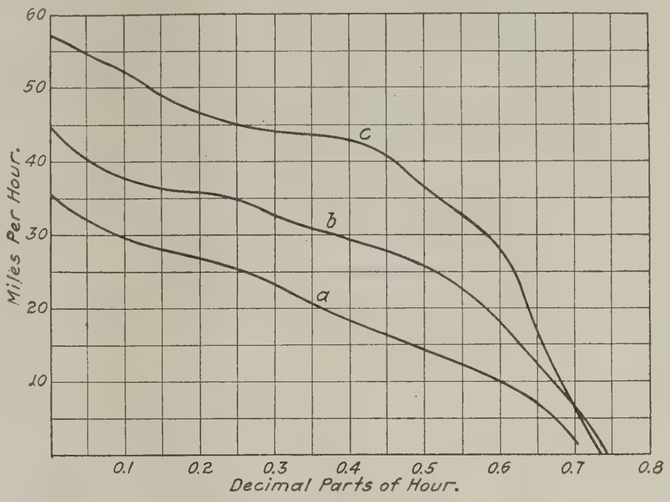


Fig. 5.—The "Run Characteristics" Shown in Figs. 2, 3 and 4 Replotted to a Horizontal Scale of Hours Instead of Minutes

The equipment on any car cannot, of course, be confined to one set of operating conditions, but must be adapted to handle any kind of service in which the car is liable to be operated. It is, therefore, evident that a compromise design must be selected, the compromise being obviously in the direction of somewhat higher full load speed and capacity than that which will give the maximum output on the worst run. Such a machine would then be suitable for cars having heavier lamp loads operating in express train service, thus facilitating the standardization of equipment.

While a more extensive investigation of schedule conditions obtaining on any particular railroad would probably give results varying somewhat from the above, it would appear that an axle generator designed for a minimum full load speed of about 24 miles per hour will in general give the best results in branch line service for a given mass and cost, and will also handle the high speed service satisfactorily.

The results of the above analysis would indicate that arguments recently advanced for designing axle lighting generators for abnormally low full load speeds at a sacrifice of rated capacity should be followed with caution.

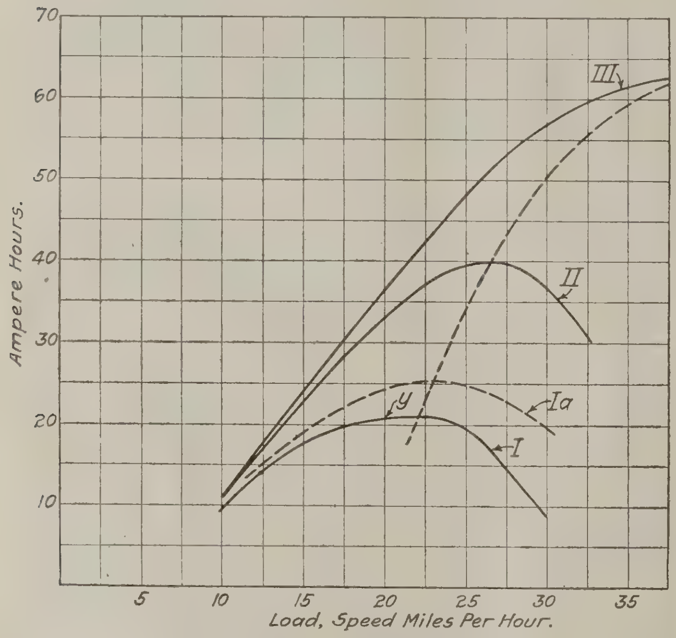


Fig. 6.—Curves Developed From Data Derived From Curves Shown in Figs. 1 and 5. The Three Curves I, II and III Correspond Respectively to the Three Runs Represented in Figs. 2, 3 and 4

It does not appear logical to design the entire equipment of a road with respect to one particular run if such design will handicap its performance everywhere else on the system, unless the reasons for such a course are very strong and conclusive.

In this connection, one of the characteristics of constant voltage control as distinguished from constant current control appears as a decided advantage in the final solution of this problem for a system involving one or two difficult runs. This advantage lies in the fact that the output of a machine controlled for constant voltage automatically increases as the battery becomes partly discharged. In other words, the machine performs as if designed for lower full load speed when operating with a partly empty battery and thus counteracts the tendency of the battery to lose its charge completely. For example, a machine controlled for constant current may under certain conditions of slow speed service give a 24-hour output less by say 10 ampere hours than that required to supply the lamp load, and those 10 ampere hours must, therefore, come out of the battery. The next day, 10 ampere hours more are taken out of the battery, and this will continue from day to day until the battery is entirely empty, and a failure results. On the other hand, if the generator is controlled for constant voltage, and fails to supply the entire lamp load the first day, its output will be somewhat greater the following day on account of the lower average state of charge of the battery, and in the course of a few days a state of equilibrium is attained and the battery ceases to lose any further. It is true that the results for this particular run will be a somewhat reduced reserve capacity in the battery; but this is better than a complete light failure. Moreover, the necessity for reserve capacity to meet an emergency, such as the loss of a belt, is far less in a short local run than on a long through schedule, and it will usually be better engineering to permit this reduction in reserve capacity under these exceptional conditions than to handicap the performance for 95 per cent of the service by designing the entire equipment with respect to such exceptional conditions.

Thus constant voltage control introduces an element of flexibility in the adaptation of one design to various conditions of service, which is a factor of no small importance in the satisfactory solution of the problem discussed in this article.

• • • •

Copyright by Underwood & Underwood, N. Y.

On the Oroya Railroad in the Andes, Peru

Power Limitation and Indication on the St. Paul*

Unique System Limits the Peak Load and Facilitates the Determination of the Amount of Power Used

THE power limiting and indicating system constitutes one of the many new and novel features developed and installed as part of the orginal equipment furnished by the General Electric Company to the Chicago, Milwaukee and St. Paul Railroad for the electrification of its Rocky Mountain and Missoula Divisions. This system has overcome so many difficult problems and performs so satisfactorily it is believed a detailed description will be of interest. A map of the electrified territory is shown in Fig. 1.

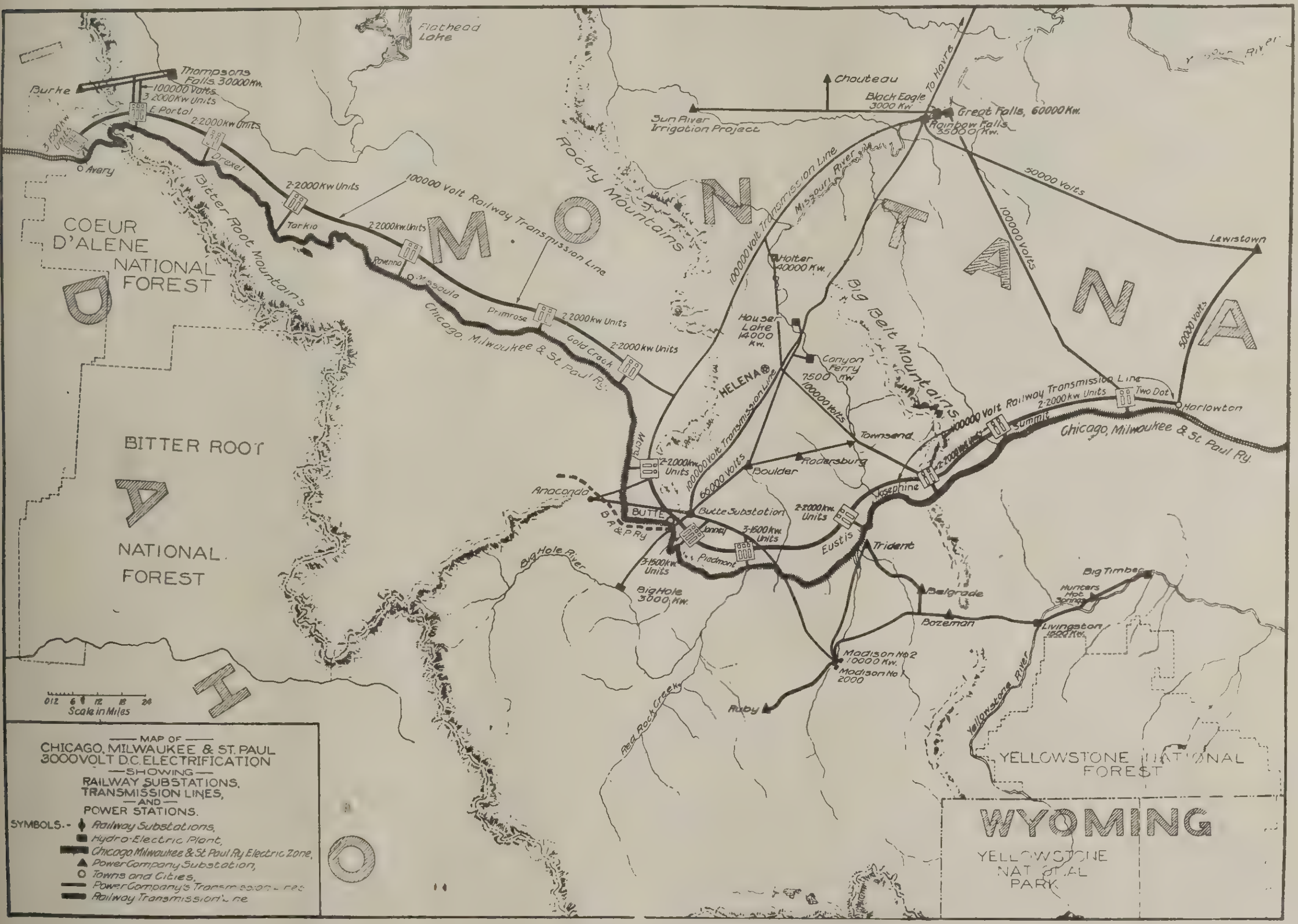


Fig. 1—Map Showing the Electrified Portion of the Chicago, Milwaukee and St. Paul Railway

Several different schemes were proposed and investigated, such as increasing the frequency of the circuit proportional to the power input, adding electrical impulses of different kinds, etc., but the system which was finally adopted and which will be described was found to be the simplest, to require the least number of pilot wires, and to necessitate very little apparatus in either the substations or the despatcher's office.

The general requirements specified by the railway were based on its desire to obtain an equipment which, with heavy trains comparatively few in number, would give the highest load-factor consistent with good railroading; and on the part of the Montana Power Company to prevent excessive peaks which might cause serious voltage variations and require the installation of excess generating apparatus to take care of the railway load. The power company was also very desirous of obtaining means by which the total power supplied to the railroad transmission line at a number of different points, over a distance of 220 miles, could be accurately recorded at one place and on one meter; to replace the former practice of having laboriously to add up records of as many as five curve-drawing meters, which are somewhat difficult to synchronize as to time, in order to obtain proper peak load data upon which to base the price of power. It is, therefore, very evident that the accomplishment of these results is of great mutual advantage and benefit to the railway company and the power company.

The 220-mile Rocky Mountain Division was selected for the first installation as being the most difficult section due to the five feeding points and the heavy grades

---

*Abstract from an article by J. J. Linebaugh in the *General Electric Review*, April, 1920.

with regenerative braking. The apparatus described was designed, built, installed, and tried out on service on this section before going ahead with similar equipment for the 220-mile Missoula Division which has only two feeding points.

The equipment of the Rocky Mountain Division as first installed was based on metering the power at the five feeding points (Two Dot, Josephine, Piedmont, Janney, and Morel Substations), but was later changed to meter the power at the low-tension side of the motor-generator set step-down transformers. This change was decided upon by the two companies concerned as it was found impossible to prevent the transfer of very large blocks of power from one of the power company's lines to the other lines through the railways company's transmission line at times of switching or line troubles with resultant losses not correctly chargeable to the railway company, added duty to the metering equipment due to the necessity of adding and then subtracting this power, excess meter capacity, etc. The Missoula Division with only two feeding points did not have these objections and power for this division is metered on the high-tension side.

The main features of the power company's transmission line, railway company's transmission line, feeding points, location of substations and train despatcher's office is shown in Fig. 2. The despatcher's office is located at Deer Lodge, Mont., the center of the 440-mile electrification, and all the indicating and recording apparatus for both divisions is installed in the despatcher's office at this point.

The complete system comprises the two separate and distinct functions of limiting the maximum power demand at the will of the train despatcher and of indicating and recording the total net power at all times. The combination of these two functions accomplishes the following remarkable results:

(1) Independent of the number of feeding points, it indicates to the train despatcher at all times the total net amount of energy being delivered to his division and it makes a permanent record for future study and as a basis for power bills.

(2) It automatically deducts regenerated power if returned to the power company's lines or transfer of power from one line to another over the railway company's transmission line.

(3) It automatically limits the amount of power supplied to the division by lowering the trolley voltage and slowing down the trains so that the maximum peak load on the system cannot exceed a certain predetermined maximum.

(4) Its maximum limit can be changed instantly, easily, accurately, and directly by the despatcher at any time without any necessity of notifying substation operators.

(5) It is capable of reducing the peak power demand by 30 per cent.

(6) If desired, the equipment can be adjusted so that the lightly loaded substations will not be affected, thereby providing the highest possible voltage for the operation of passenger trains.

(7) If desired, the equipment can be adjusted to reduce the voltage on the heaviest loaded substations at the time of peak demand (above the maximum limit) slightly in advance of the other stations, thereby tending to equalize the load on all the stations.

(8) If an excessive demand for power occurs near any one substation, the voltage of the nearest substation is automatically lowered without affecting the voltage of the other substations, dividing the load between this substation and the stations on either side.

(9) The total power fed in at any point or transferred from one power line to another or the amount returned due to regeneration can be easily taken care of by a change in the ratio of the current transformers or by an adjustment of the wattmeter rheostats.

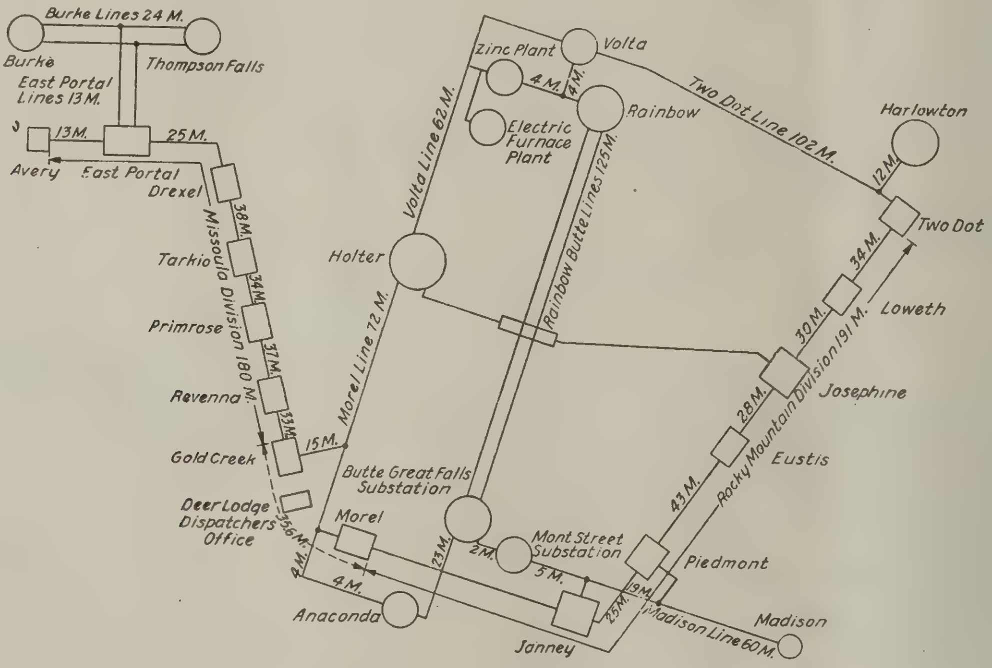


Fig. 2—General Connections of the 100,000-volt System of the Montana Power Company and Transmission Line of the Chicago, Milwaukee and St. Paul Railway, Including Location of the 3,000-volt D. C. Railway Substations

Preliminary negotiations between the railroad company, the power company, and the manufacturer were completed in November, 1915, the equipment was completed and installed for the first division in 1917, and has been in successful operation since that time. The equipment for the second or Missoula Division has been installed and is now in operation.

The system is essentially an ohmmeter on a large scale; consisting of a pilot wire circuit extending the length of the division, connecting in series all of the substations, and the train despatcher's office with contact-making wattmeters and suitable rheostats at the incoming power points, and contact-making ammeters with voltage lowering generator rheostats in each substation.

As each of the divisions were about 220 miles in length, No. 8 B & S. copper wire was selected as being the smallest wire that for mechanical reasons should be used. To give the utmost reliability, a two-wire pilot circuit was installed in each instance. This pilot wire is placed on the trolley poles beneath the 3000-volt direct-current feeders. It is very probable that one wire with a good ground return would be satisfactory, but as this was the first installation it was thought best not to take any risk of such an arrangement being unsatisfactory and therefore a complete non-ground metallic circuit was installed. The insulators were selected after a very extensive investigation of the comparative merits of porcelain and glass, leakage constants, etc., a special attempt being made to obtain an insulator which would give a minimum surface leakage under all atmospheric conditions. A 6600-volt porcelain insulator was chosen. The leakage under the most severe conditions has been so slight that the accuracy and operation has not been affected. No. 4 B & S, wire is used at all crossings.

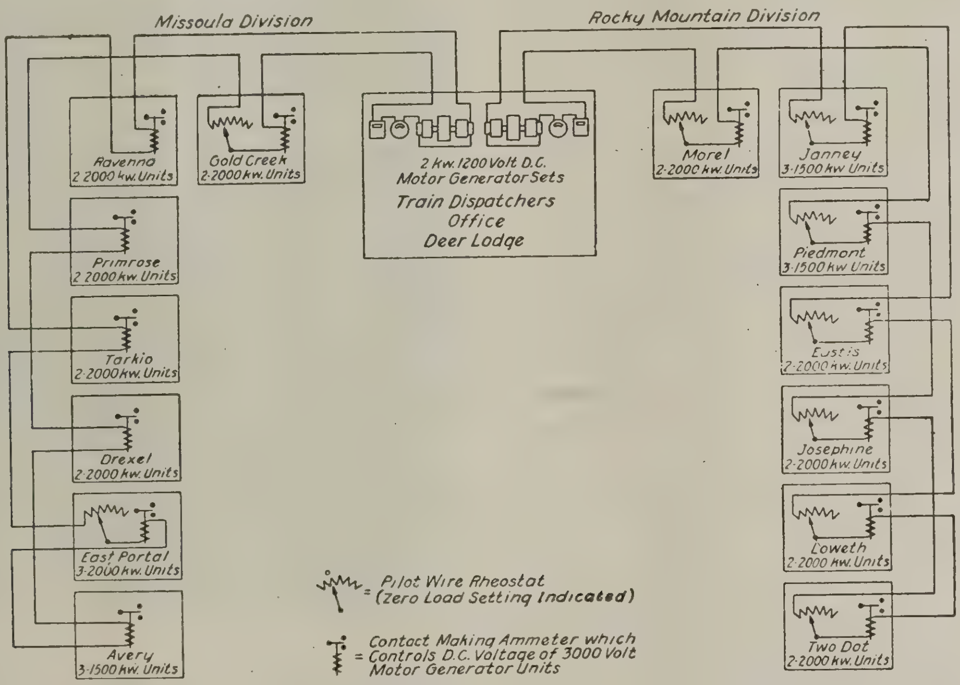


Fig. 3—Diagram Showing General Connections of the Pilot Wire Circuit and Location of the Contact-Making Wattmeters for the Rocky Mountain and Missoula Divisions

A constant source of direct-current potential is applied across the two ends of the pilot wire loop at the despatcher's office, power being obtained from a 2-kw. 1200-volt direct-current motor-generator set, the voltage of which is held constant by a standard voltage regulator The voltage applied to the pilot wire is determined by the length of the division, the resistance of the pilot wire, the number of substations, and the power feeding points.

TABLE I

MAXIMUM KILOWATT CAPACITY FOR INCOMING POWER AND REGENERATION AT EACH SUBSTATION.

Substations.	Maximum Incoming Power in Kw.	Maximum Regeneration in Kw.
Morel	10,000	1,000
Janney	10,000	6,000
Piedmont	10,000	6,000
Eustis	10,000	1,000
Josephine	10,000	3,000
Loweth	10,000	3,000
Two Dot	10,000	1,000

The equipment as finally worked out only requires a maximum of 1200 volts direct current for the 220-mile division, or 440 miles of pilot wire.

The indicating or limiting feature is obtained by inserting or removing a certain number of ohms or resistance for a definite change in the kilowatt demand which causes a definite decrease or increase in the current flowing in the circuit when a constant voltage is held across the pilot wire.

The contact-making wattmeter resistances and the pilot wire contact-making ammeters are connected in series with the pilot wire as shown in Fig. 3, which shows connections for both divisions. As the Rocky Mountain Division has the greater number of feeding points, and maximum regeneration, the equipment of this division will be described in detail.

Due to the necessity of accounting for the regenerated power from the locomotives, or the transfer of power through the 100,000-volt 60-cycle three-phase transmission line of the railway company, it was necessary to provide a so-called Zero Center Meter, which made necessary to have either the resistance for the total power or the regenerated and transferred power always in circuit at the no-load position. The total amount of power in both directions, for which it was necessary to provide resistance, is shown in Table I. It will be seen that it would have been necessary to provide resistance for a total power input of 70,000 kw. and 21,000 kw. for regeneration. In order to obtain greater accuracy it was therefore decided to insert resistance for increase of power and to have the contact-making ammeters arranged to make contact at minimum instead of at maximum current.

This arrangement makes it necessary to have only the resistance for regeneration in the line permanently, while the resistance for power input has to be available only at each wattmeter. This arrangement gives a much smaller total meter scale with greater accuracy at the loads usually obtained.

The total length of the No. 8 B. & S. pilot wire loop from the despatcher's office at Deer Lodge to the farthest substation near Harlowton is approximately 434 miles, with a total resistance of 75 deg. F. of approximately 1450 ohms.

After careful consideration of all the different factors, the equipment was designed on the basis of 15 kw. for each ohm resistance and 125 kw. for each step on the wattmeter rheostats, giving a resistance per step of 8⅓ ohms. The kilowatt settings, pilot wire voltage, current in the pilot wire, and resistance are given in Table II, from which it is noted that there are 0.237 amps. flowing in the pilot wire at the peak kilowatt setting. The contact-making ammeters are designed to make contact at this current. The apparatus is designed to hold certain definite peak limits in 2000 kw. steps from 10,000 to 25,000 kw. as indicated.

The power-indicating apparatus, with exception of the contact-making wattmeters in each substation, is all installed in the despatcher's office. The equipment in the despatcher's office consists of a 2-kw. motor-generator set, a milli-ammeter calibrated in kilowatts, a curve-drawing ammeter also calibrated in kilowatts, a curve-drawing voltmeter to give a permanent record of the pilot wire voltage, and suitable indicating instruments and switchboard to control the motor-generator set.

On account of the very small amount of power available for the operation of the curve-drawing totalizing wattmeter, a special meter had to be developed and both the wattmeter and voltmeters are based on the well-known Tapalog principle. These meters were built by the Wilson Maeulen Company, New York. The curve-drawing voltmeter and wattmeter are exactly alike with exception of the meter element.

The meter element is a standard Weston direct-current ammeter for the wattmeter, and a standard Weston voltmeter for the voltmeter. A tapping bar actuated by clockwork and dry batteries, in connection with an ink ribbon and paper roll, taps the meter needle at intervals of 5 seconds, making a small dot on the paper at the point where needle happens to be at that time. The totalizing wattmeter and the indicating wattmeter work between limits of 0.190 and 0.353 amps., calibrated for the correct kilowatts. The doors of the meter cases are equipped with switches so that the voltage is removed when the door is open. These meters produce a very satisfactory record and have given very successful operation.

Due to the reasons explained, the indicating wattmeter reads a maximum at the lowest amperes and is therefore off scale above 25,000 kw. or when no current is flowing.

The motor-generator set consists of two 1-kw. 600-volt generators connected in series for a maximum of 1200 volts direct connected to a 3-h.p. 1800-r.p.m. 110-volt 60-cycle induction motor with ⅓-kw. 125-volt exciter. Power is supplied by a 3-kw. 2300/110-volt transformer. Separate excitation at 125 volts is used with a standard regulator to obtain very close regulation. The automatic control of this regulator is somewhat special as the voltage variation covers a range from 964 to 1200 volts and must be changed at the same time as the connections of the wattmeters.

The front view of the switchboard with notations giving the function of most of the devices are shown in Fig. 4. A view of the complete switchboard as installed in the despatcher's office is shown in Fig. 5.

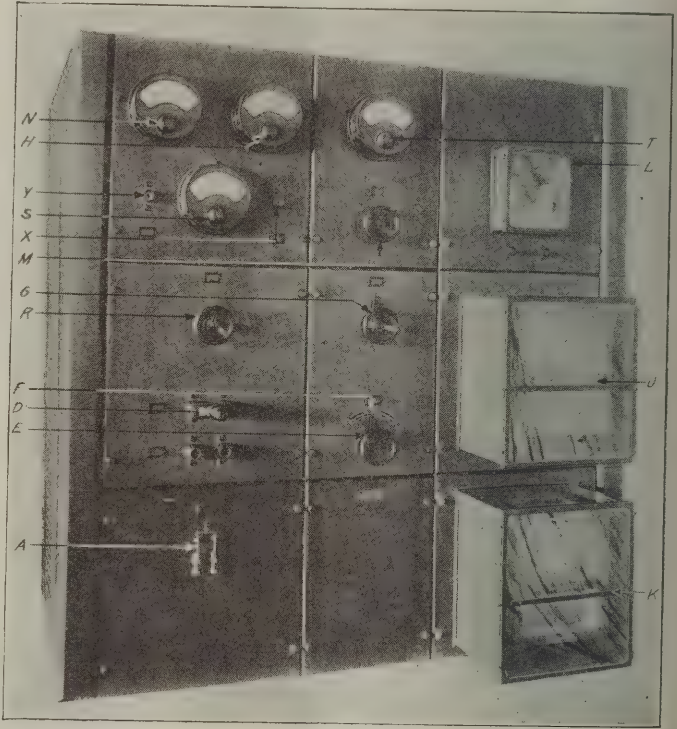


Fig. 4—Power Limiting and Indicating Switchboard: A, Induction Motor Switch; D, Plus Switch for Pilot Wire Connections; E, Hand Wheel of Kilowatt Limit Adjusting Rheostat; F, Kilowatt Limit Scale Marked from 10,000 to 25,000 kw.; G, Hand Wheel of Rheostat for Fine Adjustment of Regulator Voltage; H, Pilot Wire Indicating Voltmeter; K, Curve Drawing Voltmeter; L, Pilot Wire Voltage Regulator; M, Rheostat for Calibrating Pilot Wire for Change in Resistance Due to Temperature; N, Pilot Wire Ammeter; R, Rheostat for Hand Adjustment of Pilot Wire Voltage When Regulator is Not in Use; S, Milliammeter Used to Test for Leakage; T, Indicating Kilowatt Totalizer; U, Curve Drawing Kilowatt Totalizer; X, Plug to Short Circuit Ammeter When Testing for Possible Grounds; Y, Plug to Connect Milliammeter Between Middle Point of the Two Generators and Ground.

Due to the simplicity of the indicating wattmeters, two of these meters have been installed for each division, one on the switchboard and the other in front of the trick train despatcher. With this arrangement the despatcher can tell at a glance the exact amount of power being taken by his division at any instant and also can watch the power demand resulting from his orders to the train crews in charge of trains ascending or descending the mountain grades.

Variation in resistance of the pilot wire due to change in temperature is taken care of in the despatcher's office by a rheostat which can be easily inserted and the total resistance adjusted to 2000 ohms, the approximate resistance of the pilot wire loop and the coils of the contact-making ammeters, by holding 1200-volts and adjusting the rheostat for 0.6 amps.

The adjustable wattmeter resistances in the substations are automatically short circuited during this operation by reversing the current through the pilot wire, which action short circuits the resistance by means of a polarized relay near the top of the contact-making wattmeter unit.

The equipment for each substation at which power is supplied is exactly the same on the Missoula Division, only the wattmeters being omitted from the other substations; while the equipment for all of the seven substations on the Rocky Mountain Division are exactly alike.

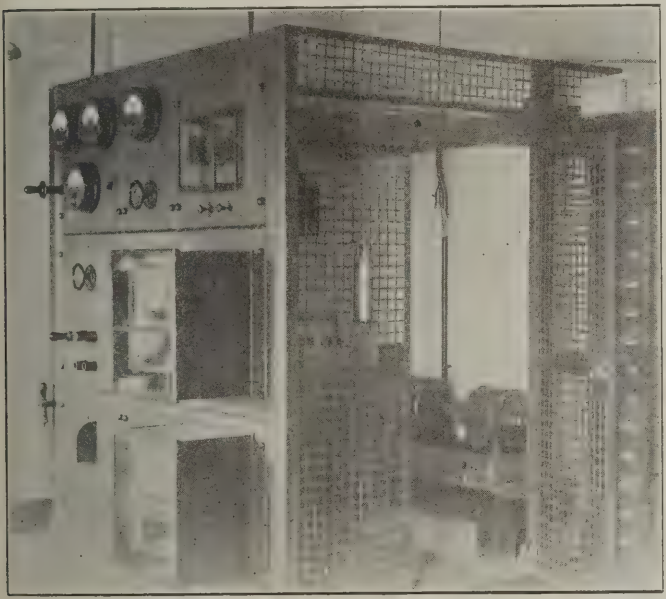


Fig. 5—Photograph of Complete Installation in the Despatcher's Office, Deer Lodge, Mont.

The contact-making wattmeter equipment consists of a contact-making wattmeter built along standard meter lines with an indicating pointer equipped with contacts and moving between the two stationary contacts. The spiral spring of the pointer is connected to the shaft of the pilot wire rheostat located immediately above the wattmeter. This shaft is driven by the motor-driven clutch mechanisms at the top of the supporting framework. When contact is made on one side, due to an increase in incoming power, the circuit is completed through the clutch coils causing the clutch to engage the rheostat gearing and insert a certain amount of resistance in the pilot wire. At the same time the wattmeter spring is wound up due to the movement of the shaft. This action continues until the torque of the wattmeter is offset by the torque of the spring when a balance is obtained and the clutch circuit interrupted thereby causing the rheostat to come to a standstill. This operation is continued for any increase or decrease in the incoming power.

The rheostats forming part of this unit have the same number of buttons with 8⅓ ohms between each button, a sufficient number of buttons being used to take care of the power requirements as specified in Table I.

The power-limiting scheme in connection with the indicating equipment consists of a contact-making ammeter for each substation with its coil connected in series with the pilot wire circuit so that when the current in the pilot wire decreases to a certain predetermined point, 0.237 amps., contact is made and resistance inserted in the exciter circuit supplying excitation to the separately excited direct-current generators by means of a motor operated rheostat. These rheostats have sufficient resistance to lower the substation voltage to a minimum of 2100 volts. When contact is made by the contact-making ammeter, the voltage of the substation is decreased and the resulting slowing down of the trains reduces the total input of the substation to a value below the predetermined peak setting. When the total load becomes less than the peak setting, the contact-making ammeter will make contact on the other side and bring the voltage of the substation back to normal. A secondary current coil forms part of the contact-making ammeter and is energized with current from a direct-current shunt in the ground or the negative side of the 3000-volt substation, so that the heavily loaded substations have their voltage decreased slightly before those with lighter loads. If the total alternating-current input is beyond that covered by the power contract, or the limit determined by the train despatcher, the voltage of all the substations will be decreased until the total input reaches the amount decided upon.

An overload and an underload relay are also connected across the current shunt. The underload relay is calibrated to make contact at about one-half load on a substation so that the limiting equipment is inoperative until the load is greater than this amount. The overload relay is set to take control of the motor-operated rheostats at three times load and prevents the load going above this amount by lowering the voltage independently of the power-limiting equipment which transfers some of the load to the substations on either side.

If the power demand should be greater that the peak limit while a locomotive is regenerating through a substation, the reverse-current relay, at the bottom of the panel in each substation (primarily used to give correct field connections of the synchronous motor-exciter) is also arranged to open one of the control circuits so that the voltage lowering rheostats are inoperative. With this arrangement the potential is held constant at 3000 volts. If the voltage should be below normal, due to operation of the power-limiting equipment, and regeneration should occur, the voltage is automatically brought back to 3000 volts and held at this value.

The maximum kilowatt peak limit or kilowatt setting can be changed at any time by the train despatcher to take care of unusual congestion or other requirements by simply varying the voltage across the pilot wire in the definite steps shown in Table 1 by means of a hand-wheel. The simplicity of this arrangement is due to the fact that the higher the voltage the greater the number of ohms which must be inserted to reduce the pilot wire current to 0.237 amps. This is clearly shown in Table II.

The different kilowatt settings are therefore obtained with certain definite voltages which must be held accurately by the voltage regulator. This is accomplished by the rheostat handwheel and the connections, which change the setting of the voltage regulator. If the voltage held should vary slightly, closer adjustment can be made with a rheostat.

TABLE II

CURRENT IN PILOT WIRE CORRESPONDING TO VARIOUS POWER LIMITS

Kilowatt Peak Limit	Volts Across Pilot Wire							Kilowatt Scale							
		0	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000	22000	24000	25000
								Milli-amperes							
25000	1200	353.0	339.5	327.2	315.8	305.1	295.0	285.0	277.0	268.5	261.0	253.5	246.5	240.0	**237.0**
24000	1184	348.5	335.0	323.0	311.6	301.0	291.0	282.0	273.3	265.0	257.5	250.0	243.0	**237.0**	233.7
22000	1152.5	339.0	326.5	314.5	303.5	293.0	283.5	274.5	266.0	258.0	250.5	243.5	**237.0**	230.5	227.5
20000	1121	330.0	317.5	306.0	295.0	285.0	275.6	267.0	259.0	251.0	244.0	**237.0**	230.5	224.0	221.0
18000	1089.5	320.5	308.5	297.0	287.0	277.0	268.0	259.5	251.5	244.0	**237.0**	230.5	224.0	218.0	215.0
16000	1058.5	311.0	299.5	288.5	278.5	269.0	260.0	252.0	244.0	**237.0**	230.0	224.0	218.0	212.0	209.0
14000	1027	302.0	290.5	280.0	270.0	261.0	252.0	244.5	**237.0**	230.0	223.0	217.0	212.0	205.5	203.0
12000	995.5	293.0	281.5	271.0	262.0	253.0	244.7	**237.0**	230.0	223.0	216.0	210.5	205.5	199.0	196.5
10000	964	283.5	272.5	263.0	253.5	245.0	***237.0***	230.0	222.5	216.0	209.5	204.0	198.0	193.0	190.5
Resistance (ohms)		3400	3533	3667	3800	3933	4067	4200	4333	4467	4600	4733	4867	5000	5067

Due to the necessity of reducing the pilot wire current to the same value, the kilowatt totalizing meters, which are ammeters calibrated in kilowatts, must record correctly the total kilowatts, although finally carrying the same amperes, i e., 0.237. This is accomplished by gearing the several rheostats together with a common rheostat handwheel. This handwheel which changes the voltage through the regulator by definite steps also changes at the same time, by definite increments, the resistance across the coils of the two kilowatt meters, thus altering the current required to give any definite scale indication in the ratio of the change made at the same time in the pilot wire voltage. By this means 0.237 amps. which is the point at which the contact-making ammeter makes contact, can be made to represent 10,000 kw., 12,000, up to 25,000 kw. by simply turning the rheostat handwheel to definite points plainly marked on the escutcheon, correctly connecting the three different circuits.

TABLE III.

COMPARISON OF CURVE-DRAWING KILOWATT TOTALIZING METER INDICATION WITH SUMMATION OF READINGS OF THE SUBSTATION CURVE-DRAWING WATTMETERS, APRIL 16, 1918

Time	Morel	Piedmont	Josephine	Two Dot	Summation Curve Drawing Meters	Curve Drawing Kilowatt Totalizer
8:00 a.m.	0	1000—	2500—	5800	2300	2100
8:30	200	200—	3400—	5800	2500	2800
10:00	0	1500	2800—	10000	7700	7750
10:30	1000	800	2800—	9000	8000	8000
11:30	2800	1000	2400—	10500	11900	11800
11:30	3000	1600	2600—	10000	12000	11800
12:00 noon	4000	3000	2800—	9600	13800	13300
12:30 p.m.	1000	2000	2600—	9000	12000	11700
1:00	1500	1600	2800—	10800	11100	11700
1:30	2600	1800	2500—	9800	11700	11300
2:00	5400	3000	3000—	11700	17100	17500
2:30	2800	0	3200—	10800	10400	10900
3:00	0	500—	2600—	11000	7900	7800
3:30	400—	500—	3200—	7900	3800	3500
4:00	1500	500—	3000—	5900	3900	3900
4:30	1500	500—	2400—	6900	5500	6200
5:00	1700	0	2200—	8100	7600	7500
6:30	4000	1500	2600—	10100	13000	13500
7:00	1000	1600	2800—	7100	6900	7600
7:30	3100	500	2200—	7000	8400	6600
8:00	4000	0	2600—	7000	8400	8500
9:00	4000	400—	3000—	7900	8500	9000
10:00	4000	0	3000—	7500	8500	9000
11:00	2000	0	2200—	8900	8700	7000
11:30	3200	0	2000—	8700	8900	9400
12:00	3600	0	3000—	7500	8100	8000
Average....	....	....	....	....	8792	8775

—Indicates power fed back to the power company.

It was thought that it might be necessary actually to calibrate the kilowatt meters on the ground after being installed by means of the standard curve-drawing meters in the different circuits but this was found unnecessary as the check readings, taken with all the equipment installed exactly as laid out, indicated that these meters are as accurate if not more so than the standard meters. Table III gives a record of a large number of readings taken before the contact-making wattmeters were changed to the low side of the step-down transformers. These readings show remarkable accuracy as no special pains were taken to synchronize the clocks of the different curve-drawing meters which probably accounts for some of the greater variations. It should be kept in mind that this record was made when equipment was first placed in operation and that the four feeding points were located along the railway line over a distance of more than 200 miles, being the first time that power supplied by more than one line was added and recorded on one meter over such a great distance. It is therefore evident that the power supplied by any number of transmission lines over practically any reasonable distance can be accurately indicated and recorded in this manner.

The curve-drawing kilowatt totalizing meter reaches correct readings more quickly than the standard curve-drawing switchboard-type wattmeters in the substation and consequently gives a better detailed record of the load.

The lowering of the trolley voltage in the substation is accomplished slow enough, by proper speed of the motor-operated field rheostat, as not to affect the operation of the trains objectionably, the only result being gradual slowing down of the train.

Additional power limiting is also obtained by instructing the freight engineers to drop back to the series connection of the locomotive motor if very low trolley voltage is indicated by the voltmeters in each locomotive cab.

Several different peak settings have been tried out from time to time during the last two years to ascertain the correct peak limit for different service conditions. Some of the lower settings slowed down the trains to such an extent as to be objectionable on account of overtime of train crews or delay in passenger trains. It was found that peak settings could be obtained which would prevent excessive peaks and still maintain good operating voltage practically all the time, giving load-factors which have never before been obtained for similar service in electric railway operation. The peak limit was set at 14,000 kw. for the Rocky Mountain Division on April 1, 1919, and operation has been very satisfactory on this basis. The average load-factor per month for six months is given in Table IV, or a total average load-factor of 56.8 per cent, which is a unique showing for railway operation and which confirms the wisdom of the railway company in specifying and installing the equipment described in this article.

TABLE IV

SUMMARY OF PERFORMANCE OF POWER-LIMITING AND INDICATING SYSTEM FOR SIX MONTHS—ROCKY MOUNTAIN DIVISION.

Date 1919	Time Peak Limit Hours	Per Cent Peak Time of Actual Running Time	Load-factor
April	43.6	6.4	59.3
May	32.6	4.6	56.1
June	6.1	1.6	56.5
July	4.6	0.77	55.6
August	26.7	4.1	54.7
September	65.8	9.5	58.8
Average	....	....	56.8

The railway company pays 0.526 cents per kilowatt-hour for 60 per cent of the peak irrespective of whether this amount is actually used. The load-factor maintained is so near 60 per cent that the increase in cost of power or the cost of power not used is very slight. With increase in the number of trains, the load-factor will be raised and no difficulty should be experienced in holding a load-factor of 60 per cent or better.

One of the great indirect benefits obtained is the valuable assistance the indicating equipment gives the train despatcher in despatching trains in such a manner as not to give excessive peaks and thereby lowering the voltage due to the power-limiting equipment. By careful train despatching so that one train is ascending the mountain grade while another train is descending, it is possible to assist the automatic equipment in maintaining a good load-factor very materially and to greatly increase the efficiency of the general operation of the railroad.

American Welding Society Holds First Annual Meeting

The American Welding Society held its first annual convention in the Engineering Societies Building, 33 West 39th Street, New York on Thursday, April 22. The morning session was devoted to society business and announcement was made of the election of officers. J. H. Deppler was elected president, J. W. Owens was elected vice-president for two years, and D. B. Rushmore was elected vice president for one year.

A plan of action for the American Bureau of Welding for the coming year was discussed at the afternoon session. It was proposed to reduce the representation of the American Welding Society in the American Bureau of Welding. A committee was authorized to lay down a scheme of organization and to prepare a program for the coming year.

Comfort A. Adams, chairman of the bureau spoke briefly on the subject of welded joints for pressure vessels. A point of particular interest was brought out in this in connection concerning the use of different kinds of welding machines. Mr. Adams showed that within the limits of arc length consistent with good practice in electric welding, it made no difference whether the machine used was a constant current, constant heat or constant unit heat machine.

Mr. Adams statement was in effect as follows: In the case of the constant heat machine the current is decreased as the arc is lengthened. The constant current machine maintains a constant current for any length of arc within the limits of the machine. In the case of the constant unit heat machine the current increases as the arc is lengthened. Owing to the fact that the arc spreads out and covers a greater area as it is lengthened it is necessary to increase the current to maintain a constant heat for unit area. Theoretically this would be the ideal machine, but within the limits of arc length consistent with good practice, the variation of current is practically a negligable quantity.

The objective of the bureau's activities will be to determine how a good weld can be assured. Methods will be sought for testing the quality of a weld after it is made and for determining the best way of eliminating locked up stresses in long welds. At present the greatest hope lies in controlling the conditions under which the work is done. This will greatly reduce the amount of nitrogen in the weld. Heat treatment is beneficial in that it tends to break up the combined nitrogen.

The afternoon session was concluded by an announcement that a number of manufacturing companies had offered to assist the bureau with its research work. Much of this work is in a partially finished condition.

Speed of Metal Arc Welding

At the evening session, three papers were presented and discussed. The first paper presented was "The Speed of Metal Arc Welding" by William Spraragen of the department of electrical engineering of the University of Washington. On account of the absence of Mr. Spraragen, who had been called away to the Pacific coast, the paper was read by E. A. Miller. In substance the more important portions of the paper are covered in the following statements:

The range of metal arc welding or rather the range of application of metal arc welding is very large. At one time it was considered necessary to scrap metal parts that were worn away. Autogenous welding is responsible for the discontinuance of this practice to a large extent. Without a doubt the welding operator is a most important factor in successful arc welding and, of course, the more skillful the operator the more and the better work will be turned out. It is very desirable to be able to compute the rate at which arc welding may be accomplished, but the complexity of the different elements entering into it are such that it is very difficult to calculate the time required to produce certain kinds of joints. For inside work, 1.8 lb. of metal deposited per hour is a reasonable estimate, but when the work is performed outdoors there appears to be a reduction in the amount of metal deposited so that the average is 1.2 lb. of metal deposited per hour for outdoor work. This reduction in the amount of metal deposited is probably due to the cooling action of the air.

With reference to the type of welding apparatus used, whether it be alternating current apparatus or direct current apparatus, it is estimated that where first class welding operators are employed there is no difference in the speed between the two kinds of equipment.

In a few words of explanation the retiring president, Comfort A. Adams, explained that the paper on the speed of arc welding was based upon conclusions arrived at by tests made by the General Electric Company in welding up some 10½ tons of welding material. This work was done just prior to the signing of the armistice and while the work had been cut up into coupons, ready for testing, the tests have not been made up to the present time.

Automatic Arc Welding

The second subject for the evening was "Automatic Arc Welding Machines" by H. L. Unland, of the Power & Mining Engineering Department of the General Electric Company. Mr. Unland stated that the automatic control of arc welding was not new. He said that the automatic arc welding machine had been developed for the reason that it was desirable in turning out large quantities of duplicate parts to make this operation as nearly mechanical as possible. As a precedent he mentioned that years ago the General Electric Company had developed a similar machine for a gas cutting process which was used in the making of small gears, wheels, etc. Operators, cutting by hand, frequently ran over the line; these factors influenced the company to take up the question of mechanical feed and a satisfactory cutting torch was eventually produced. At that time it was found that the gas consumption was reduced to one-third and that the speed was increased four or five times over the time required for hand work.

The development of the automatic arc welding machine is merely an extension of the same principles into another field and for sections that are being turned out continuously the mechanical feed is the proper thing to use. Mr. Unland described the General Electric's machine and with the aid of numerous stereopticon slides explained very carefully the operation of the various circuits used in the control of the welding wire to the work.

Gas Cutting

The third paper on Recent Development in Gas Cutting by Stuart Plumley of the Davis Bournonville Company was not read, but Mr. Plumley spoke briefly of the more important developments. The most successful development has been the cutting of cast iron with the gas torch. Cutting cast iron is particularly difficult because the oxide of iron melts at a higher temperature than the iron itself. The cutting is now accomplished by preheating the oxygen.

It is so easy to break cast iron that gas cutting is not often desirable, but it can be used to excellent advantage for such operations as cutting a frozen blast furnace cap.

Discussion

The discussion brought out the fact that the rigid method was used for welding tanks with the automatic electric welding machine. The statement was made that locked-up stresses were greatly reduced by reason of the fact that the speed of welding was very high. It was further stated that alternating current cannot be adapted successfully to automatic welding as a sensitive variable speed motor is required for feeding the metal into the arc.

Training of welding operators with the alternating current arc was advocated on the ground that because the alternating current arc had to be held within closer limits, the welders trained to use the alternating arc make better operators than those who receive their initial training with the direct current arc.

Electrification of the Haut-Rhin Railways of France

An article in the "Times Engineering Supplement" states that the electrification of the Haut-Rhin railways around Belfort, France, have been completed. The electrified section is approximately 44 miles long. The gage is one meter and the gradients are fairly good. On the other hand there are numerous curves of small radius, many of 165 ft. and some even of 130 ft. These sharp curves were adopted as a means of lessening the cost of construction. The single phase system at 6,000 volts has been adopted owing to its easy transformation and simplicity of distribution. The power is obtained from the steam station of the Societe des Houilleres de Ronschamp; steam power having to be used as no water power was available. This station is situated about 12½ miles from Belfort, and has one turbo-generator of 5,000 hp. and three of 2,500 hp. each. It uses as fuel a mixture of best coal and pit slack.

The motor cars of the trains have two motor-trucks, each carrying two 4-pole motors of 35 hp. each. For each motor car there are four traction motors, a feeding transformer, and electrically operated air compressor for the air brakes, and pantograph and the accessory fittings for heating and lighting.

The single phase slip-ring motors have two principal stator windings. One is an excitation winding, the axis of which is perpendicular to the line of short-circuit brushes, and one is a transformation winding in the brush line. It is held that the selection of this type of motor is justified by the advantage it possesses over other types of single phase motors. In comparison with ordinary series motors it has the advantage of an armature circuit which is electrically independent of the primary circuit. Thus, the tension of the latter can be selected freely in such a way as almost always to allow of the regulation of the feeding current within reasonable limits. The regulation of the speed is effected by varying the voltage at the terminals of the motors. These are constantly in parallel and can be fed at 310, 415, 500 or 550 volts.

The traction motors develop a power of 35 to 40 hp. in continuous work for one hour without the heating exceeding 75 deg. above that of the outer air. They drive the axle through gearing having a 1 to 4.93 ratio and give the car at 750 r. p. m. a speed of 20 miles an hour, the diameter of the car wheels being 33½ in. Since the first motor cars were put into service, they have performed a daily run of about 135 miles without excessive heating of the motors or the transformers. The transformer of 140 k. v. a. is suspended under the body of the car between the two trucks. It is of the armored type and has a primary winding for the 6,000-volt, 25-cycle current and two secondary windings one of which, giving 120 volts, is used for the lighting and heating of the car as well as for operating the compressor motor and the contactors. Multiple unit control is used.

This system has worked with such entire satisfaction that further extensions are planned. The installation as a whole affords a striking example of making electric traction economically possible and successful by means of co-operation with an industrial source of power supply.

Electrification of Brazilian Railways

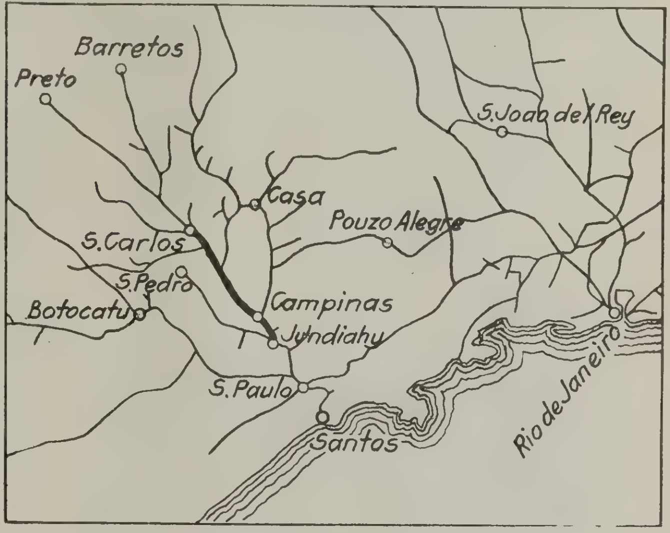
The announcement has been made of the proposed electrification of the Paulista Railway between Jundiahy and Campinas, Brazil, a distance of about 28 miles. The road is of double track construction and the total mileage including switches and extra track amounts to 76 miles. The track gage is 5 ft. 2 in.

The International General Electric Company has secured a contract amounting to nearly $2,000,000 for this electrification project. The equipment to be supplied consists of 12 locomotives, eight freight and four passenger engines, material for the transmission line and sub-station and a 3,000-volt overhead, a type similar to that used on the Chicago, Milwaukee & St. Paul. It is one of the largest railway contracts received since the St. Paul electrification.

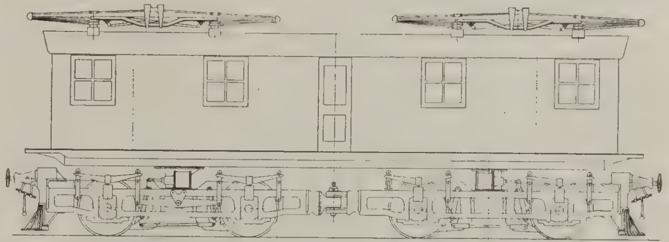
This project anticipates further extensions amounting to 100 additional miles of route which may eventually bring the total electrification up to 128 miles extending between Jundiahy and San Carlos.

Power for the operation of the lines will be supplied by the San Paulo Light & Power Co., at 88,000 volts, 60 cycles.

The locomotives will be of the geared type, 3,000-volt direct current. The freight locomotives will weigh 100 tons each, all weight on driving axles, and the passenger engines 120 tons, equipped with two axle guiding trucks at each end. They will be built at the Erie Works of the General Electric Company. All of them will be equipped with regenerative braking apparatus. The design of the power and distribution equipment will parallel closely that used on the St. Paul electrification, while the locomotives will be almost the duplicates of those used on the Butte, Anaconda & Pacific Railway, except for slightly increased weight and the addition of regenerative braking.



General Location of the Section of the Paulista Railway to Be Electrified



Type of General Electric Locomotive to Be Used

The Westinghouse Electric International Company has also contracted to supply four electric locomotives —two for passenger service and two for freight service. The passenger locomotives have a one hour rating of 2,000 hp. and weigh 121 tons. They are designed for a maximum speed of 65 miles per hour.

The freight locomotives have a one hour rating of 1,500 hp. and will weigh 87 tons. They are also operated from a 3,000-volt, d. c. overhead trolley system and will be complete with regenerative control. The maximum speed will be 40 miles per hour.

It is expected that the new line will be in operation in July, 1921.

Direct Current Starters and Controllers

Description of Typical Apparatus Designed to Meet the Requirements in Various Kinds of Service

By Gordon Fox

THERE is such a wide variety of commercial starters and controllers that all cannot be described. General types will be discussed and typical devices illustrated. Direct current manual starters and controllers are constructed in multiple switch designs, face plate designs and drum designs.

The multiple switch starter comprises a number of switches, closed by the operator in sequence to cut out the accelerating resistance in a number of steps. The last switch short circuits the accelerating resistance entirely. The switches are specially designed with laminated leaf contacts so that when released by their holding-in device, they will all fall by gravity to the open position. They are ordinarily held in the closed position by a catch which in turn is held by a small magnet. This magnet introduces the no-voltage protection feature. Upon failure of voltage the magnet is de-energized, dropping the catch and returning the switches to off position. The switches are provided with a mechanical interlock feature so that they cannot be closed except in proper sequence. The multiple switch starter is a very good type, especially for the larger size motors. A considerable time period is required in closing the switches giving a degree of protection against too rapid acceleration. The presence of a number of switches in parallel tends to prevent heating of the contacts particularly that of the last switch. Upon opening, the switches quickly break any arc which might tend to form. Auxiliary contacts are provided to protect the laminated contacts from this arcing. Fig. 1 illustrates a multiple switch starter for a 40 hp. motor. Fig. 2 gives the diagram of connections for this starter.

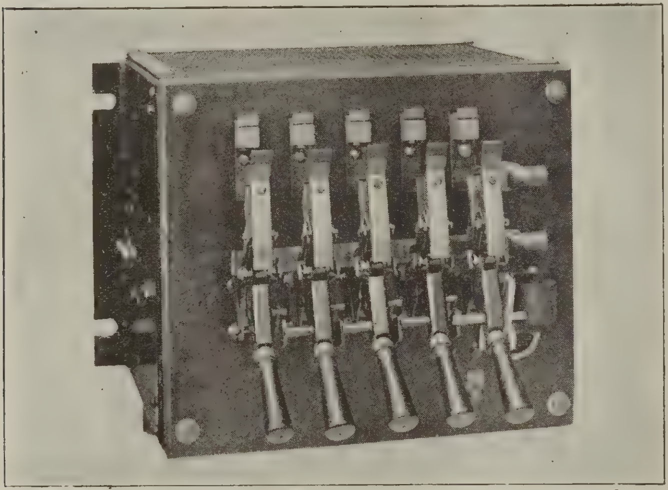


Fig. 1—Multiple Switch Starter for Direct Current Motor

Face plate starters predominate in the small motor field, primarily because of their simplicity and cheapness The ordinary starter of this type comprises a lever carrying contacts which slide over and make contact with flat segments attached to an insulating plate. Fig. 3 illustrates this type of starter as supplied for different sizes of motors. Fig. 4 illustrates a similar starter having its contact parts enclosed. The lever is held in running position by a retaining magnet. Upon failure of voltage this magnet releases the lever which is returned to off position by a spring. On all except the smallest starter laminated auxiliary contacts are supplied to shunt the face plate contacts in the running position to prevent overheating. A device is also supplied to introduce a quick break of the arc resulting when the starter is returned to off position with power on, or the arc resulting from discharge of the shunt field inductive energy. Fig. 5 is a diagram of connections for a face plate starter for a 10 hp. motor.

Face plate starters are frequently used where speed control by armature resistance is required. Arrangement is then made so that the starting lever may be left on any intermediate position. In an ordinary starter the lever will return to off position unless held by the operator at an intermediate point or turned to full running point so that the retaining magnet may function. In the armature regulator a notched segment is used, this segment being held by the no-voltage release magnet. This segment acts to retain the lever at any notch at which it is set. Upon failure of voltage the starting lever is released, returning to off position by action of a spring. Fig. 6 illustrates an armature control starter or regulator for a 5 h. p. motor. The resistance is self-contained and much more bulky than that supplied with the

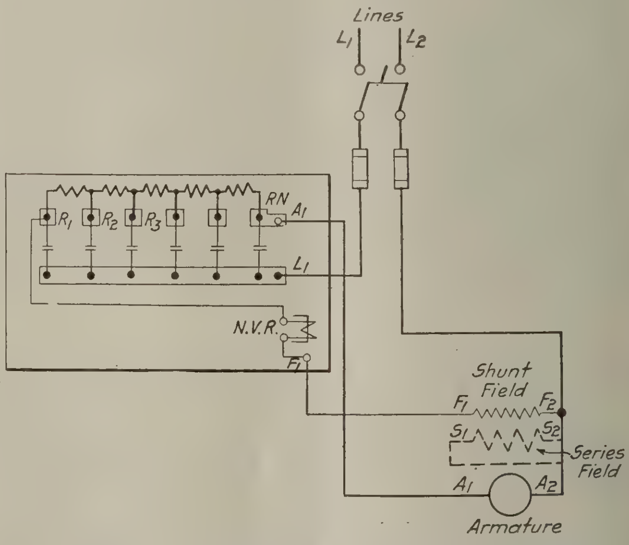


Fig. 2—Diagram of Connections of Multiple Switch Starter for Direct Current Motor

ordinary starter. The ordinary starter is limited to approximately 15 seconds starting duty at infrequent intervals. The resistors of the armature regulator must pass motor load current continuously. This type of starter finds its greatest application, perhaps in connection with fan drives for heating and ventilating systems.

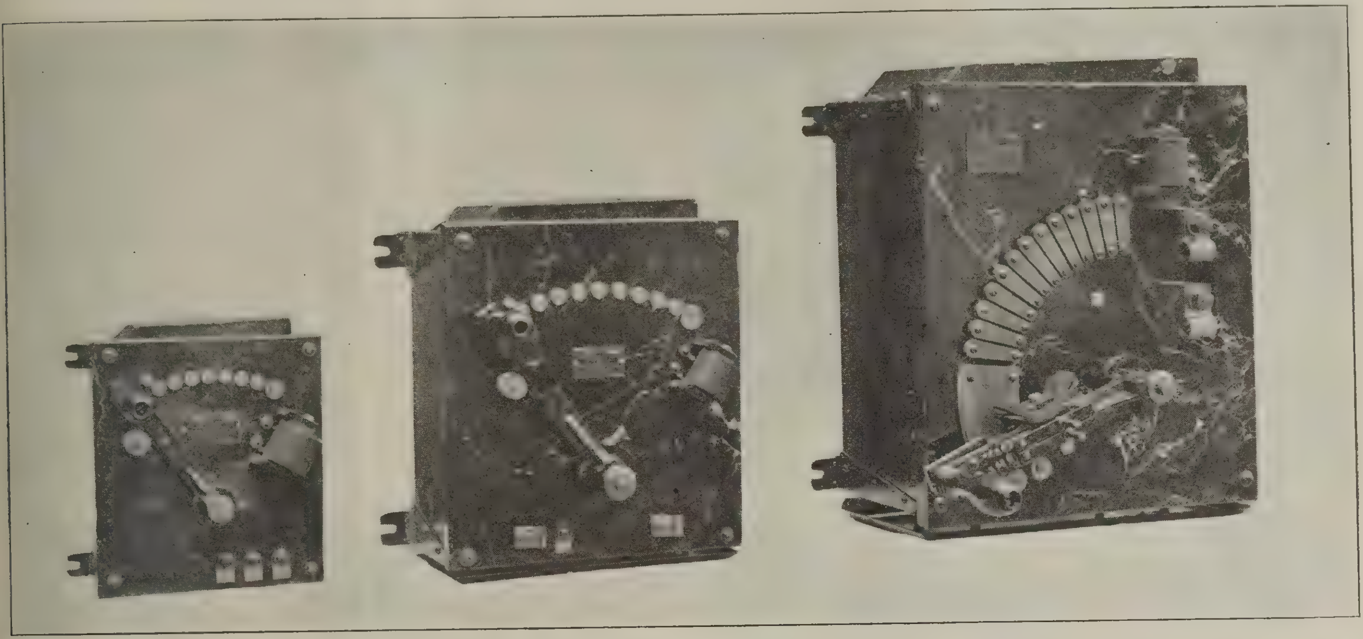


Fig. 3—Face Plate Starters for Direct Current Motors of Various Sizes

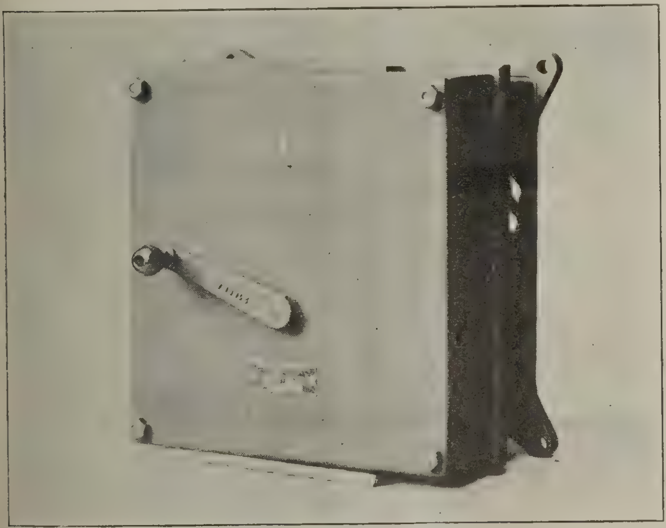


Fig. 4—Enclosed Face Plate Type Starter for Direct Current Motor

Adjustable speed direct current motors require both a starting device and a means for adjusting the strength of the shunt field. Face plate starters are available, which include the necessary field rheostat for speed adjustment. These starters are so constructed that the motor is first accelerated to normal speed with full field. The no-voltage magnet then retains the starting arm while the field control arm is moved across the field rheostat element, speeding up the motor. Upon failure of voltage, both arms return to off position. Fig. 7 illustrates a starting and field adjusting rheostat for a 10 hp. motor and Fig. 8 gives the diagram of connections for this starter.

The face plate design is not restricted to the field of small motor starters. A number of more pretentious controllers are built on this principle. These controllers vary considerably in layout and design, according to purpose. They are more rugged in construction than simple starters as they are subjected to more continuous manipulations. They are generally laid out for reversing operation, being provided with two or more sets of segments so connected as to reverse armature or field connections. Magnetic blow out coils are provided to help extinguish arcs at the contacts as the circuits are opened in stopping or reversing. The resistors are usually contained in a frame integral with the controller. Fig. 9 illustrates a simple reversing controller of this type. Fig. 10

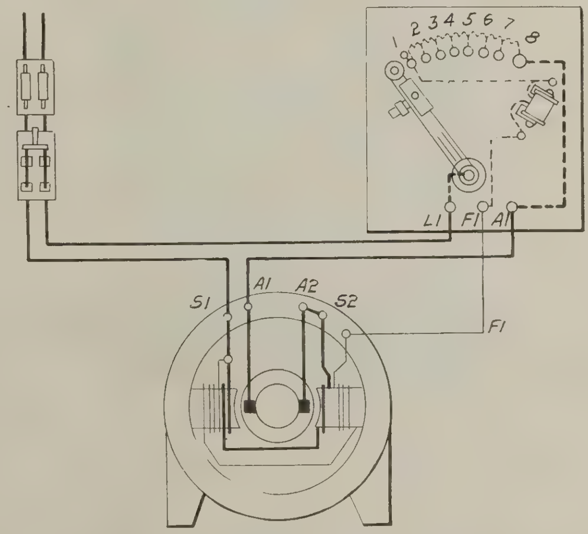


Fig. 5—Diagram of Connections; Face Plate Starter for Direct Current Motor

gives the diagram of connections for this controller.

Controllers of this type are used most commonly with series or heavily compounded motors, since these motors are best suited to manipulating drives. The advantages of the face plate controller are simplicity, ruggedness, ease of operation and ease of speed control. The disadvantages are, lack of protection to motor due to pure manual control of acceleration, lack of flexibility in layout, severity of arcing, exposure of live parts, large space occupied and lack of protective devices.

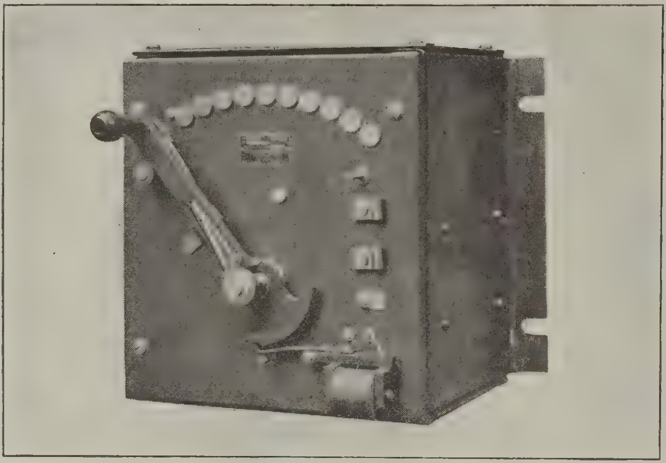


Fig. 6—Face Plate Type Armature Resistance Regulator for Direct Current Motor

A drum controller comprises essentially a cylinder upon the surface of which are exposed a number of conducting segments which may be connected to or insulated from one another, as desired. One or more series of flexible contact fingers, generally insulated from each other, are arranged to contact with the segments as the cylinder is revolved. By proportioning the arc covered by the respective segments and their position about the cylinder, the contacts can be made of desired duration and in a desired sequence.

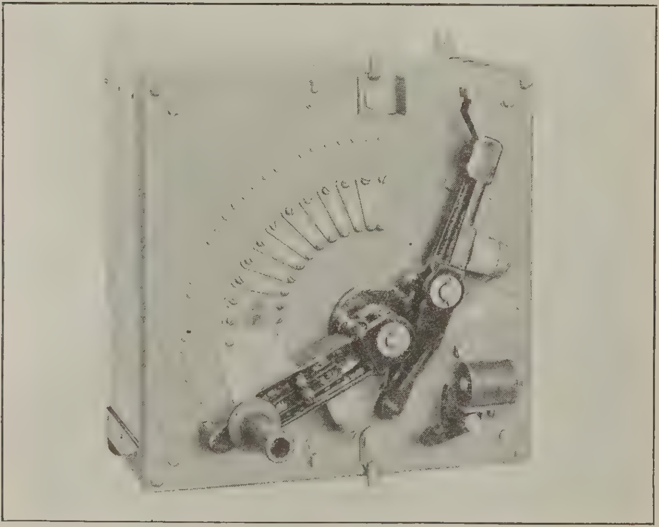


Fig. 7—Face Plate Type Starter and Field Rheostat for Direct Current Motor

The drum controller is a flexible design and is capable of many ramifications. The two most common designs are probably simple reversing controllers and hoist controllers. In the simple reversing controller contacts are supplied which serve to reverse either armature or field leads, as the drum is moved to the "forward" or "reverse" position; other contacts cause the accelerating resistance to be cut out in a series of steps. With this type of controller, operation is the same for both directions of rotation. Two distinct sets of segments are employed, one for forward, the other for reverse operation. Ordinarily, a single set

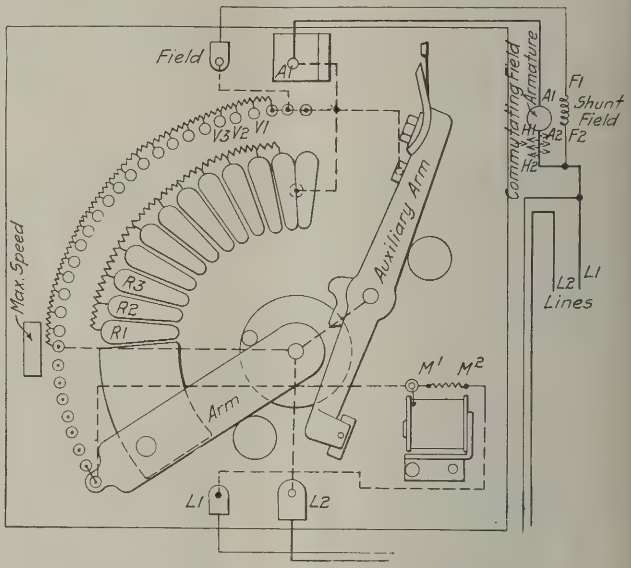


Fig. 8—Diagram of Connections; Face Plate Starter and Field Rheostat for Direct Current Motor

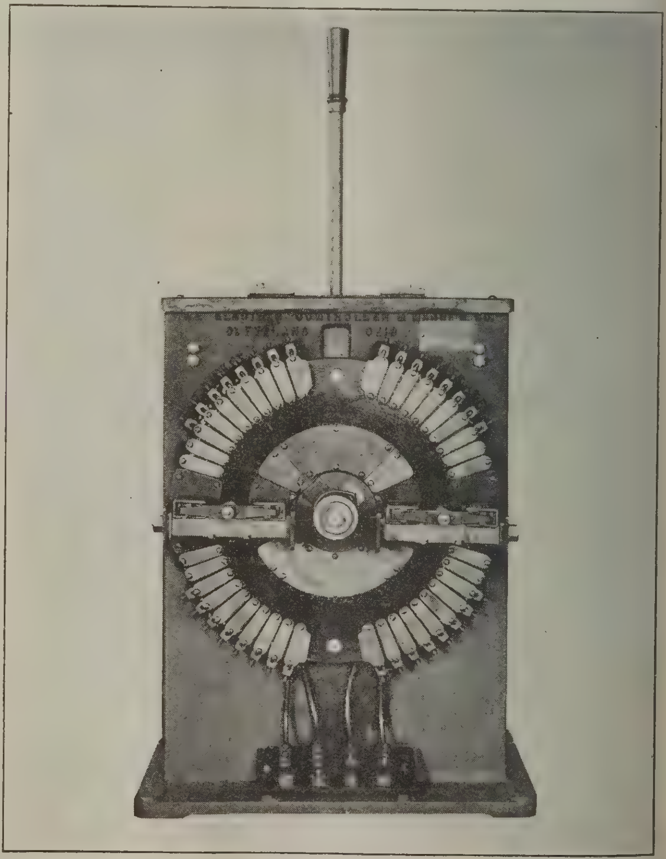


Fig. 9—Face Plate Type Controller for Direct Current Motor

of finger contacts with the two sets of segments selected according to the direction of throw of the cylinder or drum are all that are required. A drum controller has a number of "positions" corresponding to steps or changes in connections at the segments. These positions are distinguished by providing a "star wheel" and roller lever actuated by a spring. The roller drops into the grooves of the star wheel as the drum is revolved, distinguishing the various steps and preventing operation with the drum located at intermediate points, where contacts would be uncertain. Fig. 11 illustrates a drum controller for a 25 h. p. motor. Fig. 12 shows the connections for a simple reversing controller used in connection with a compound wound motor. The segments are shown in a developed view. The controller is shown in the off position; the dotted lines show the position of the finger contacts for the various other positions of the controller.

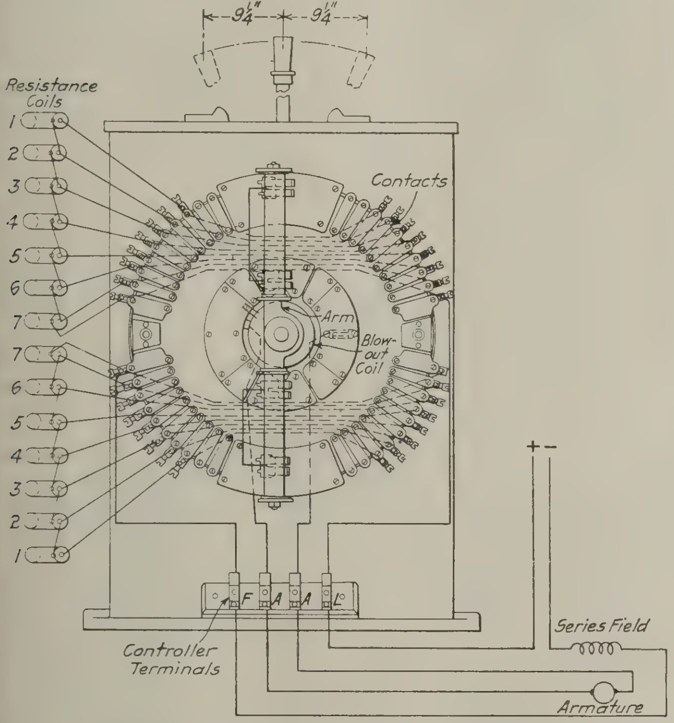


Fig. 10—Diagram of Connections; Face Plate Type Reversing Controller for Direct Current Series Motor

In order to prevent severe arcing when the circuits are interrupted, drum controllers are commonly equipped with magnetic blowout coils, which set up a magnetic field causing the arc to be extended and thus extinguished just as if "blown" by a blast of air. The blowout coils are commonly connected in the main circuits of the controller and are inactive when the drum is in the off position after the current is fully interrupted. In addition to the blowout coils, arc shields are supplied between segments to isolate the arcing and prevent short circuits due to this cause. The enclosing covers are removable to give access for inspection and maintenance and renewal of fingers and segments. The resistors are usually mounted separately, a number of connecting leads being required between drum and resistors.

The crane hoist controller is a type in which a different sequence of connections is made for foward and reverse positions of the drum. The forward or "hoist" position is arranged similarly to an ordinary reversing controller, simple acceleration and speed control by armature resistance being employed. In the reverse or "lower" position an armature shunting principle is employed, the series field being connected across the line in series with resistance. On the first point the armature is shunted by the very low resistance of the series field giving a slow lowering speed but providing a positive downward drive of the hook. As the drum is rotated to subsequent

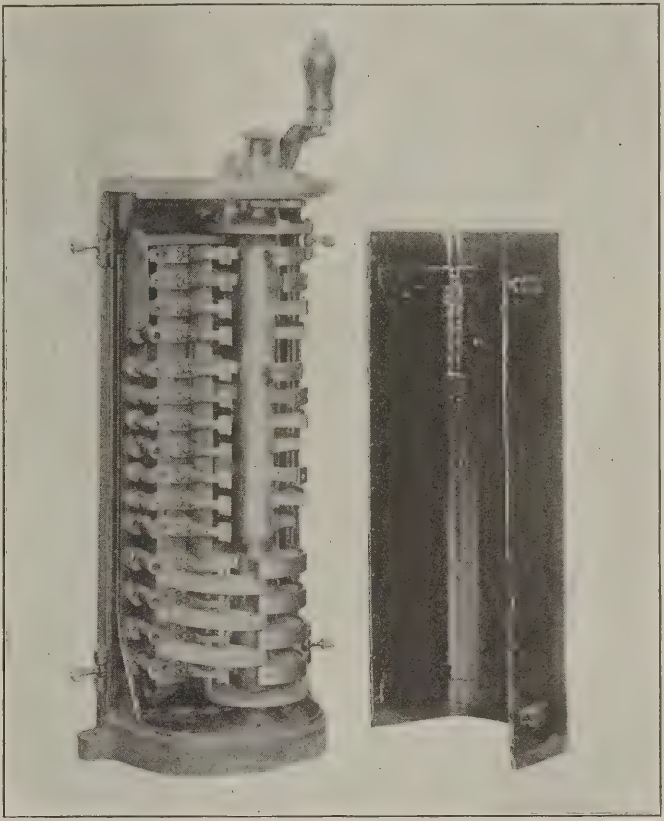


Fig. 11—Drum Type Controller for Direct Current Motor

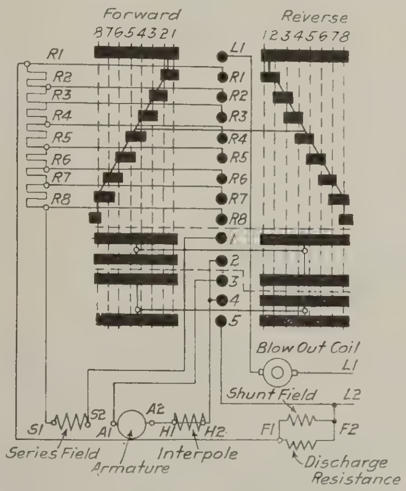


Fig. 12—Diagram of Connections; Simple Reversing Direct Current Drum Controller

positions the resistance of the armature shunt circuit is increased. This causes the armature voltage to increase so that the armature speeds up. The current in the motor armature may be either motor current, driving the light hook downwards, or generator current caused by the loaded hook tending to drive the motor downward, raising the countervolts above the impressed volts and thus reversing the armature current. Fig. 13 gives the diagram of connections for a simple drum type crane hoist controller. This is worked out to show the conditions existing when lowering.

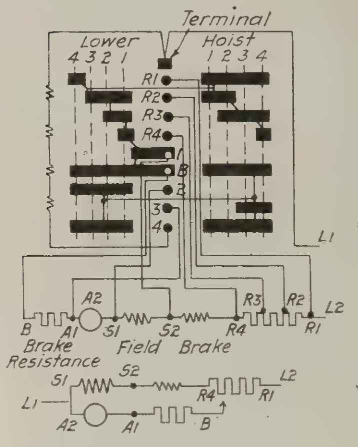
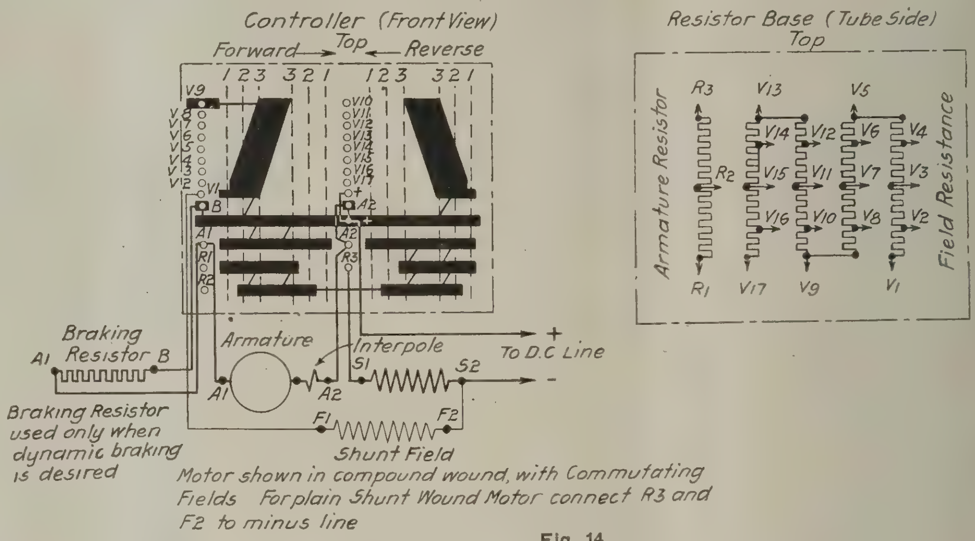


Fig. 13



Motor shown in compound wound, with Commutating Fields For plain Shunt Wound Motor connect R3 and F2 to minus line

Fig. 14

Fig. 13—Diagram of Connections; Drum Controller for Crane Hoist Duty
Fig. 14—Direct Current Drum Controller for Adjustable Speed Machine Tool Motor

The drum controller has been developed for the control of machine tool motors. It is quite extensively applied in this field. For constant speed motors the drum includes only armature reversing and accelerating points. If the motor controlled is of the adjustable speed type, a field rheostat feature is included, usually by means of a face plate housed within the drum and operated by the same handle. Fig. 14 shows the connections for a drum control of an adjustable speed machine tool motor.

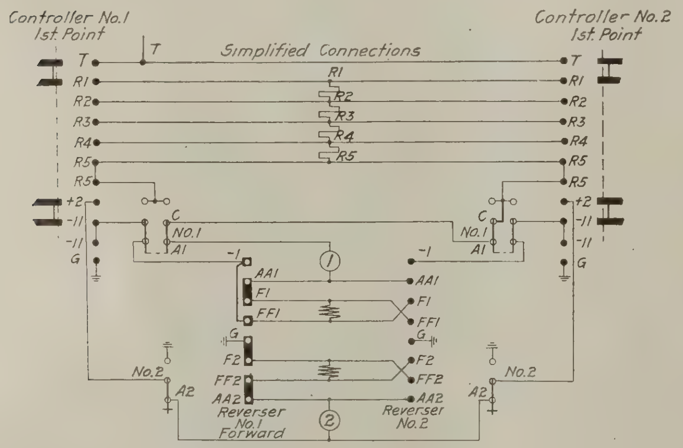


Fig. 15—Diagram of Connections; Two Drum Controllers and Two Reversers for Series—Parallel Operation of Two Motors—Railway Service

The drum controller finds extensive application in railway service, where it is commonly arranged to connect two or more motors first in series and then in parallel, with accelerating resistance supplied to limit the current while accelerating the motors from rest to full parallel operation. Fig. 15 shows a diagram of connections for two such controllers as applied on double end cars.

Drum designs are used, not only for direct manual controllers but also, in the smaller sizes, for master switches to handle the control circuits of magnetic controllers. These will be considered more fully in the later discussion.

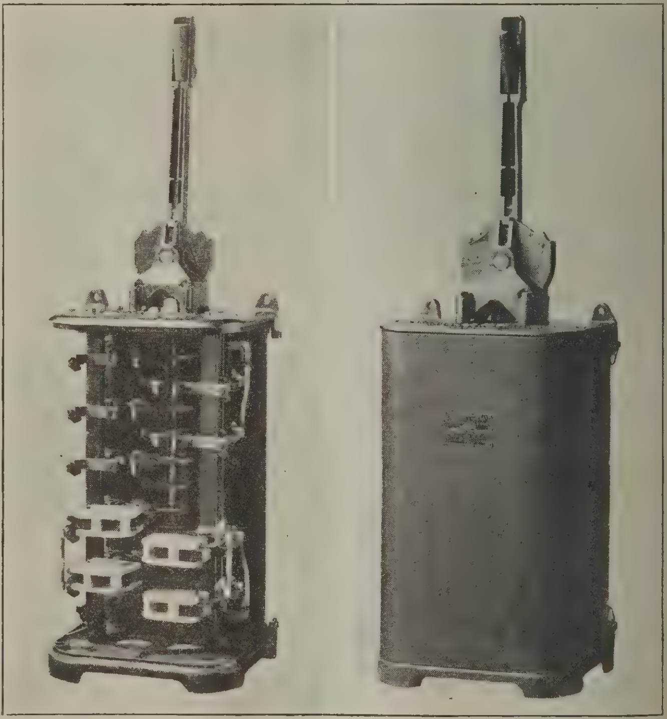
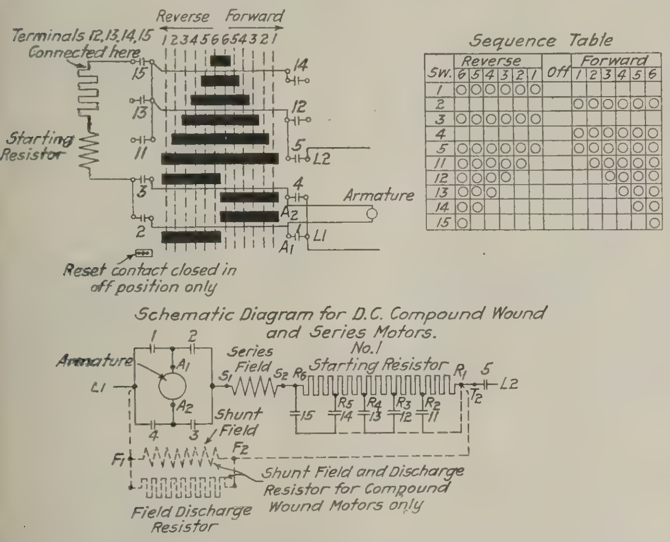


Fig. 16—Cam Type Drum Controller for Direct Current Motor

A considerable disadvantage of the ordinary drum controller rests in the fact that the contact fingers must slide on the drum segments, producing wear and introducing arcing if the segments become roughened. More serious, perhaps, is the fact that the contacts are broken slowly and the separation between finger and segment is not great, so that it is difficult to avoid some arcing, resulting in rapid deterioration of contact parts. In an endeavor to overcome these faults inherent in the drum design, a controller has been produced, similar to the drum controller in appearance but quite different in mechanism. In this controller a number of contactor units are provided, these units being held normally open by springs. The drum shaft is provided with a series of cams, each cam working in conjunction with a lever on one contactor unit. The cams are so profiled and so angularly located as to actuate the levers to produce the desired action of the individual contactor units. It may be seen that this design offers the flexibility of arrangement of the drum controller together with quick breaking contacts and easily renewed contact parts. Fig. 16 shows the make up of a cam type drum controller while Fig. 17 is a diagram of connections for a standard reversing drum controller of this type.



Sequence Table

Sw.	Reverse 6	5	4	3	2	1	Off	Forward 1	2	3	4	5	6
1	○	○	○	○	○	○							
2								○	○	○	○	○	○
3	○	○	○	○	○	○							
4								○	○	○	○	○	○
5	○	○	○	○	○	○		○	○	○	○	○	○
11	○	○	○	○	○				○	○	○	○	○
12	○	○	○	○						○	○	○	○
13	○	○	○								○	○	○
14	○	○										○	○
15	○												○

Fig. 17—Diagram of Connections; Cam Type Drum Controller for Direct Current Motor

Controllers of the drum type are sometimes arranged to be driven by a small motor which, in turn, may be governed either manually or automatically from some remote point. By this means a prescribed sequence of events can be provided. The drum may control the main motor circuits directly or it may serve as a master to govern the operation of a magnetic control.

Let the railroads make money. Let any railroad make big dividends if it can. It is not probable that the management of that railroad will settle back in the easy chair and let the profits flow in. No, the management will work itself to death to make the road bigger and stronger and serve the public better and earn more dividends, and get in more capital and earn yet more dividends. What the country needs most is larger transportation capacity.—*Lewiston (Me.) Sun.*

Metallic Arc Welding Electrodes

By J. Churchward, Metallurgist
Wilson Welder & Metals Company

In the February, 1920, issue of the *Railway Electrical Engineer* there is an article by E. Wanamaker and E. R. Pennington on Electrode Materials for Metallic Arc Welding. After going over this article carefully, the writer considers it would be well to take issue with certain statements.

Messrs. Wanamaker and Pennington state, "A limited carbon content is permitted in mild steel electrodes, mainly in order to include the average mild steel electrode material." In order to make a weld having a high tensile strength, it would seem necessary to the writer to have a certain amount of carbon left in the weld.

On page 57 under the subhead *Carbon*, appears the following statement: "Furthermore, as practically all carbon present in electrode material is lost in passing through the arc, its presence does not seem essential in welding electrodes for bare wire welding." The amount of carbon in the weld made with Wilson Welder & Metals Company's electrode No. 9 is approximately .25 per cent carbon.

In the last sentences of the same paragraph the authors state: "On the other hand, the maximum carbon content usually permitted for bare electrodes is 0.18 per cent. If the carbon content is much higher than that amount it has a bad effect upon the behavior of the arc, unless the electrode has been specially treated." The writer would like to emphasize the fact here that welding electrodes are a special high quality product and it is necessary to use the highest quality steel and special manufacturing processes to give the welding public the best possible product.

The following is "Table I" in the article by Mr. Wanamaker and Mr. Pennington, which the writer would like to correct.

TABLE I

Chemical Composition of Metal in Electrodes

Trade name of electrode	Per cent carbon	Per cent manganese	Per cent phosphorus	Per cent sulphur	Per cent silicon	Per cent copper
Page Steel "Armco Iron"	0.01	0.025	0.005	0.025	0.005	.....
Norway	0.049	0.021	0.025	0.007	0.08	.....
Central Steel, "Sweedox"	0.05	0.18	0.04	0.04	0.05	.....
Siemund Wenzel Co.	0.10	0.30	0.05	0.05	Trace	.....
Roebling Company	0.13	0.47	0.025	0.025	0.020	.....
Wilson No. 6	0.15	0.60	0.04	0.04	Trace	0.25

The analysis of Wilson No. 6 should be carbon .30, manganese over .60.

In the paragraph on manganese, Messrs. Wanamaker and Pennington state, "The presence of this element up to 0.50 per cent is generally permitted. Above that amount manganese, like carbon, has a detrimental effect upon the behavior of the arc. It also has a great affinity for oxygen and when present in an electrode, used for bare wire welding, a very large per cent of it is burned out. It is claimed by some that a little manganese in the electrode adds to the tensile strength of the weld. On the other hand, the presence of manganese very much above 0.50 per cent causes brittleness in the weld, unless the metal is protected from the effects of the air."

Our metallurgist and engineers discovered as far back as 1915 that the actual loss of manganese going through the arc depends on the current value and the wattage in the arc; that is, the higher the wattage the more rapidly is the manganese volatilized and therefore the lower the percentage of manganese in the weld, thus reducing the strength and ductility. They also found that the greater the fluctuation of the current value, the greater the irregularity of the per cent of manganese in the weld. When the current is not under control the per cent of manganese is reduced to a trace in the weld.

Numerous experiments have proved that by changes in current value with the same metal electrode the fractured surfaces of the weld show alternate layers of burned and unburned steel, thus showing the importance of manipulating the current in such a manner that the weld will contain enough manganese to protect the steel and provide for the required physical properties. We have also determined that the same character of arc that is detrimental to the manganese content is also detrimental to the carbon content.

The authors claim that manganese has a detrimental effect on the behavior of the arc. This is questionable; in fact, as high as 1.25 per cent manganese has been used with absolutely no detrimental effect on the arc. They state that manganese has a great affinity for oxygen, and when present in an electrode used for bare wire welding, a very large per cent of it is burned out. This is a well-known metallurgical fact, except that it states that a large per cent is burned out. The writer has found that with a wire having an analysis, carbon .40 per cent, manganese 1.00 per cent, the resultant weld will show approximately .25 per cent carbon, .80 per cent manganese. In this case only 20 per cent of the manganese is oxidized.

TABLE II

Carbon and Manganese in the Electrode and in the Deposited Metal

Analysis of electrode		Analysis of deposit	
Carbon	Manganese	Carbon	Manganese
.20	.56	.12	.26
.20	.60	.11	.35
.39	1.01	.23	.84
.39	1.01	.20	.88
.41	.88	.19	.53
1.15	.35	.79	.22

If the welding wire has a high enough carbon and manganese content, so that when metal passes through the arc there will be a large excess left there, above that which is lost, there will be very little oxide in the weld, as all the oxygen coming in contact with the molten metal forms carbon and manganese oxides, which go off in gases.

That a "little manganese adds to the tensile strength of the weld," is not claimed by the writer, but with .80 per cent manganese the writer claims considerable increase in strength and ductility, as shown in Table III.

TABLE III

Tests in Tension of Welds Containing .80 Per Cent Manganese

Elastic limit, lb. per sq. in.	Tensile strength, lb. per sq. in.	Elongation, in.	Brinell
38,450	66,750	18 per cent	153
42,800	62,650	21 per cent	159
42,200	66,300	21 per cent	153
43,150	68,600	21 per cent	149
44,800	65,600	20 per cent	146
46,150	64,800	20 per cent	153

That "the presence of manganese very much above 0.50 per cent causes brittleness in the weld, unless the metal is protected from the effects of the air" is not clear, as the manganese itself protects the metal from the air by forming volatile gases.

Table II should be carefully studied in comparison with this statement (by Messrs. Wanamaker and Pennington): "By referring to these tables it will be noted that practically all of the carbon and approximately 70 per cent of the manganese is burned out. The fact that a little manganese passes through the arc into the weld may account for the claim that a manganese-bearing electrode will add to the tensile strength of the weld. On the other hand, the great tendency for this element to cause oxidation may offset any gain in tensile strength by an increase in brittleness."

It has always been the experience of the writer that manganese prevents oxidation, rather than causes it. If there is an element which oxidizes rapidly, forming a volatile gas, such as manganese and carbon do, it surely protects the metal from being oxidized and also prevents the oxides from entering the weld, as such oxides go off in gas.

Messrs. Wanamaker's and Pennington's paragraph on copper indicates that they have misunderstood the reason for a copper content in welding electrodes. Copper is added to welding electrodes to increase the tensile strength, and to protect the weld from oxidation.

TABLE IV

Physical Tests With and Without Copper

Tensile strength with copper. Lb. per sq. in.	Tensile strength without copper. Lb. per sq. in.
66,140	59,430
62,580	59,610
64,070	57,420

Quoting further from Messrs. Wanamaker's and Pennington's article, "Most electrode specifications for bare wire welding are intended only to limit the carbon, manganese, and other impurities." This fact is indicated in the electrode specification prepared by the welding committee of the Emergency Fleet Corp., revised Dec. 20th, 1918, as in Table V.

TABLE V

Limit of Chemical Composition for Bare Wire Electrodes

Carbon	Not over 0.18 per cent
Manganese	Not over 0.55 per cent
Phosphorus	Not over 0.05 per cent
Sulphur	Not over 0.05 per cent
Silicon	Not over 0.08 per cent

At the time the above specifications were drawn up it was specifically stated that the reason the limits were held at .18 carbon and .55 manganese, was because any welding electrodes of a chemical composition above that stated, infringed the patents of the Wilson Welder & Metals Company, and therefore, could not be included in general specifications. This is also true of the present specifications of the American Welding Society.

In conclusion, the writer will try to give a few methods and suggestions which may help in ordering welding electrodes. In the first place, the electrode must have the proper welding characteristics. In order to test these characteristics, it is suggested that the buyer try a portion of each coil or bundle of wire for overhead welding. With a fairly efficient operator, a wire with the proper characteristics should make a bead overhead easily, (that is, without any undue trouble). The bead should be flat and perfectly sound, that is, without any gas holes. It has been found that an electrode which does not give these characteristics in overhead welding is very liable to make a poor weld in flat welding.

The buyer should decide what tensile strength and what ductility is needed on his particular work, and should order wire from concerns who guarantee this.

If the above rules are followed, it is certain that the buyer will be satisfied with the electrode material, which he purchases, provided it comes up to these specifications.

Alternating Current Theory and Practice

A Brief Practical Review of Basic Principles Prepared for Railroad Electrical Workers.

By O. C. Callow

V. Mutual and Self-Inductance

In preceding chapters it has been shown what an alternating current is and how it is produced; a study will now be made of some of the properties peculiar to an alternating current circuit, the first being *Inductance.*

Inductance plays a very important part in alternating current circuits and should therefore be studied at length. The subject may be divided in two parts. One part deals with mutual induction, meaning the electromotive force induced in one conductor by its close proximity to another conductor carrying an alternating current. The other part considers self-induction, meaning the electro-motive force induced in the conductor itself through which the alternating current is flowing.

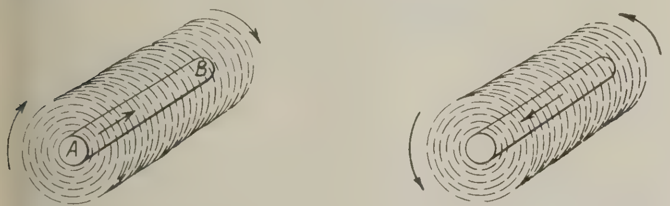


Fig. 1—Showing Magnetic Field Around Any Alternating Current Conductor

It is a fundamental that when a current flows through a conductor, a magnetic field is produced surrounding it. This field will be found to exist evenly around the conductor in a direction governed by the direction of the current in the conductor as shown in Fig. 1. The strength of the field produced will depend upon the current flowing through the conductor. Thus in Fig. 1, if a heavy current is flowing, the lines will produce a dense field represented by a large circle around *AB,* but only by a small circle when a small current is flowing. Since we know that the strength of the current in an alternating current circuit is continually varying, from zero to maximum and changing in direction once every cycle, the field produced around the conductor will be in continuous movement, contracting and expanding, contracting to zero, changing in direction, expanding again and so on, for each cycle. Fig. 2 shows the instantaneous values of the field produced around a conductor during one cycle showing the relation between the field strength and the current curve.

It has been shown previously that if a conductor be moved across a magnetic field so as to cut the lines of magnetic force, that a voltage will be generated in the conductor. The same effect can be produced if, instead of moving the conductor to cut the magnetic field, the field be moved so that the lines of force are cut by the stationary conductor.

If a second conductor or conducting material be located in close proximity to a conductor carrying an alternating current so that this second conductor will be in the magnetic field produced by the current carrying conductor, then the lines of force which have been shown above as expanding and contracting in circles around the conductor will cut this second conductor, producing a voltage in it as stated above.

Referring to Fig. 3 we have the conductor *AB,* carrying the alternating current, and producing a magnetic field as shown. Conductor *CD* is located in the path of the lines of force and will be cut by them as they expand or contract. Let us now consider the direction in which the induced voltage in the conductor *CD* is flowing. If the current in *AB* is increasing and flowing in a direction as shown on Fig. 3, then the lines of force will be expanding. These lines will therefore commence to cut *CD* as they expand from the left hand side and will travel through it in a downward direction. This will be equivalent to moving *CD* to the left across the magnetic field. By applying the right hand rule to find the direction of the voltage induced in *CD,* we note that with the lines of force flowing downward and the equivalent direction of motion of the conductor being to the left, that the voltage will flow in a direction which is opposite to the flow of the current and voltage in the conductor *AB.*

When the current in *AB* has reached its full strength, it will be producing a magnetic field which will still cut *CD,* but will produce no voltage in same, since the lines of force will be neither expanding or contracting. With an alternating current flowing in *AB,* this will only take place momentarily at the maximum value.

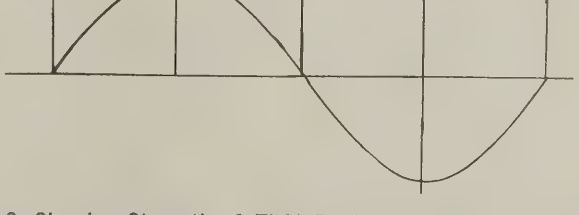


Fig. 2—Showing Strength of Field Produced Around a Conductor During a Cycle

As the current in *AB* commences to fall the magnetic field around it will contract, and the lines of force will once more cut the conductor *CD* and induce a voltage in it. Since the field is contracting, the lines will commence to cut the conductor *CB* from the right hand side in a downward direction, which will be equivalent to moving *CD* to the right across the magnetic field. Again applying the right hand rule to find the direction of the voltage in *CD* we have the lines of force flowing downward as before, the equivalent direction of movement of *CD* will now be to the right, the induced voltage in *CD* will therefore flow in the same direction as the voltage and current in the conductor *AB*.

It has therefore been shown that, while the current is increasing in a conductor, a voltage will be induced in any conductor in close proximity to it, the direction of this voltage being opposite to that of the voltage and current producing the induced voltage. Again, while the current is decreasing in a conductor the induced voltage in any other conductor will be in the same direction as the current and voltage producing the induced voltage. This induced voltage will depend upon three conditions. First, the frequency of the alternating current in the conductor *AB*, since the more often the direction of the current is changed per second, the more voltage will be induced. Second, the relation which the conductors *AB* and *CD* have to one another in regard to distance apart and method of winding, parallel or in coils, and third, the nature of the material which surrounds the conductors.

Consider the simplest case of two straight conductors running parallel through the air such as *AB* and *CD* in Fig. 3 as in a overhead transmission line. The induced voltage in *CD* would not be very great, and could be practically eliminated if the conductors could be separated several feet. If the two conductors were to be wound in the form of coils, one over the other, each turn of the coil carrying the applied alternating current would induce a voltage in each turn of the other coil. This will illustrate the second condition. It is known that air is a poor conductor of magnetism, therefore the magnetic field produced by a conductor which is surrounded by air will be much weaker than that produced by a conductor surrounded by a good conductor of magnetism such as iron. Hence if we were to wind the two coils around a core of iron, we would find a very strong field produced by the conductor carrying the applied current, and hence the induced voltage would also increase.

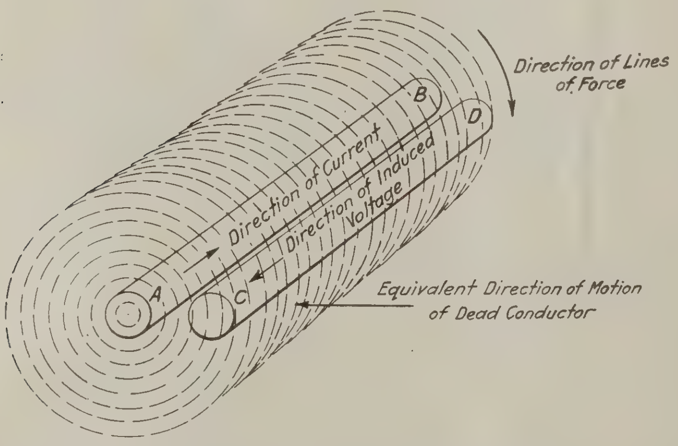

Direction of Lines of Force
B
D
Direction of Current
Direction of Induced Voltage
A
C
Equivalent Direction of Motion of Dead Conductor

Fig. 3—Showing Direction of Induced Voltage in Dead Conductor While Applied Current Is Increasing

We therefore find that two conductors, in close proximity, but having no electrical connection with one another, may have a voltage and current induced in one by passing an alternating current through the other. This is the principle upon which the transformer and induction coil are based which both owe their existence to mutual inductance.

Let us refer now to the second part of this subject mentioned, namely, self-inductance. We have seen above that the lines of force which were expanding and contracting from the centre of conductor *AB* in Fig. 3, cut the conductor *CD* and induced a voltage. This being the case, these same lines of force will also cut the conductor *AB* itself, since they commence at the centre of it. This can be understood by referring to Fig. 4, which is an enlarged view of the end of the conductor *AB*. While the current is increasing and the lines of force expanding, a voltage will be induced in *AB* exactly similar as shown above in the conductor *CD*, the direction of this voltage being opposite to the direction of the applied current and voltage. Again, while the applied current is decreasing and the lines of force contracting, a voltage will be induced in *AB* flowing in the same direction as the applied current and voltage. The direction of flow of these induced voltages can be determined by applying the right hand rule, all the forces being in the same relation in *AB* as in the conductor *CD*.

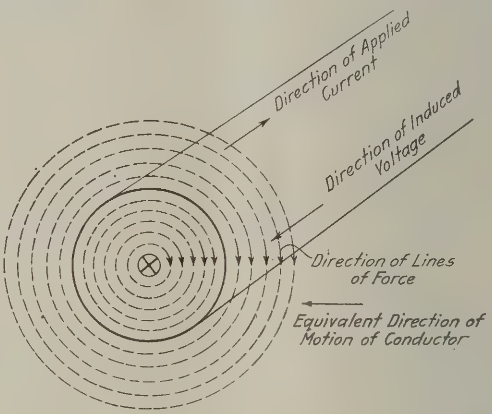

Direction of Applied Current
Direction of Induced Voltage
Direction of Lines of Force
Equivalent Direction of Motion of Conductor

Fig. 4—Showing Direction of Induced Voltage in Conductor While Applied Current Is Increasing. Induced Voltage Opposes Applied Current Tending to Prevent the Increase

Since the induced voltage has been found to flow in the opposite direction to the applied voltage while the current is increasing and in the same direction while it is decreasing, it can be said that it opposes any change in the value or direction of the applied current. This can be better understood by considering first a steady current flowing in a conductor, in which case there will be no induced voltage. This current is then increased, and at once a voltage is induced in the conductor in the opposite direction to the applied current tending to oppose the increase in current. If the current is lowered instead of increased, a voltage will be induced in the conductor which will flow in the same direction as the applied current and thus oppose the change by tending to keep the applied current from falling in value. This effect is known as self-inductance and is present in any conductor carrying an alternating current. Like mutual inductance, the amount of self-inductance will depend upon the frequency of the circuit, the form in which the conductor is wound and the nature of the material surrounding the conductor. Hence the self-inductance of a coil wound upon a iron core will be much greater than one having a non-magnetic core, since there would be more lines of force to produce this self-inductance.

Inductance in an alternating circuit can be considered in a like manner to resistance, since it is always present in the circuit, and produces a similar effect, causing a drop in the voltage in a circuit in a similar manner to resistance. This being the case, it is necessary that the inductance in a circuit be measured in some manner. The unit of inductance is known as a *henry,* and it is a fundamental, that, one *henry* will exist in a circuit when a current changing at the rate of one ampere per second induces a pressure of one volt in the circuit. Again it can be said that a coil will have an inductance of one *henry,* when the number of lines of force produced multiplied by the number of turns in the coil will equal 100,000,000 when a current of one ampere is flowing. This can be written in the following formula:

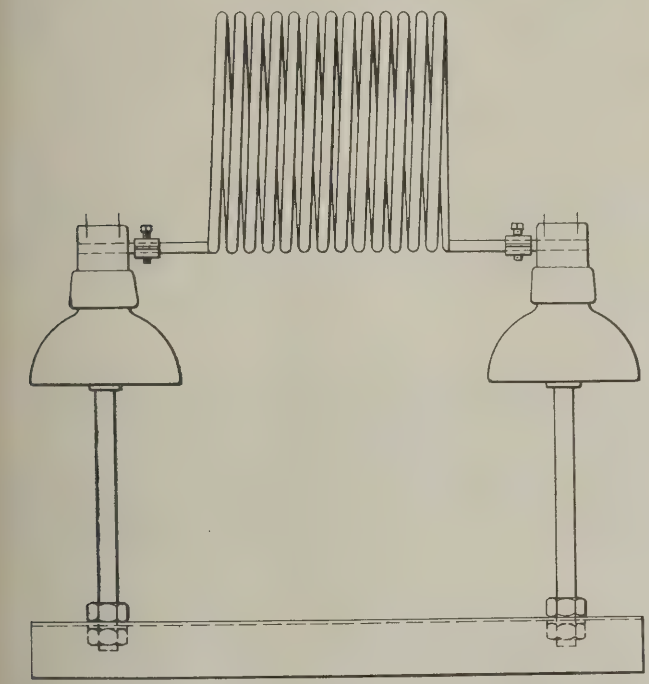


Fig. 5—Choke Coil for Indoor or Outdoor Use on 50,000-Volt Circuit —For Use with Electrolytic Lightning Arresters

$$\text{henrys} = \frac{\text{magnetic flux} \times \text{turns}}{\text{current} \times 100{,}000{,}000} \text{ or } L = \frac{N \times T}{10^8}$$

when,

L—Coefficient of self-induction in Henrys.

N—Total number of lines of force produced in the coil by one ampere.

T—Number of turns of the coil.

Thus if a coil had a coefficient of self-induction of one *henry,* it would mean that if the coil had one turn, one ampere would produce 100,000,000 lines of force through it.

From these formulas it will be seen that the inductance of the circuit depends largely upon the number of lines of force. Hence it is usual to consider a circuit which contains only lamps or resistance coils which have no iron cores as non-inductive circuits, since the inductance would be very small and can be neglected in most cases with this type of load.

In practice an inductance coil is often referred to as a choke coil, since it chokes back the applied current. These coils are largely used in connection with high tension transmission lines as an auxiliary to the lightning arresters. The coil consists of a 20 turns or so of copper wire with an air core, having a large inductance and a small ohmic resistance, similar to Fig. 5. Its function is to hold back the high frequency of the lightning discharge from the electrical apparatus until the lightning arresters discharge to ground.

The Operator's Side of Efficient Welding

By J. M. Riker, Electric Welder,
Pennsylvania Lines, Toledo, Ohio

IN the March issue of the *Railway Electrical Engineer,* Mr. John C. Weis brings out several points wherein a bad job of welding results from the work of careless operators. These statements are to be admitted as facts, but there are, however, several conditions that will make a good operator careless. Having been in the welding game for more than four years and having made a study of electric arc welding, both on the job and from various books, papers and magazines, I would like to emphasize some points on the welding operator's side that are very essential in producing a weld that will pass any inspection and will prove itself by holding up any length of time that is required of it.

I accepted a job in a railroad shop a year ago, and when I first went to work the foreman told me that the welding operators before me had always complained that the machine was not any good. Although that was not very encouraging news for me I took it as a statement only, remembering that any machine is only as good as an operator is capable of using it, be it good or bad. I soon found out to my satisfaction that the operators must have been at fault in not knowing how to operate it, for I have had no trouble to speak of with this same machine and have used it continually for a year. I can, therefore, say that it is very essential to learn your machine.

All machines do not work alike. Constant current, motor generator sets are more in use than any other types. These machines will vary in current so that an operator who has welded with one machine using 35 or 40 volts and 100 or more amperes, cannot expect to go on another machine and get the same results without first trying it out. If he is a real mechanic he can tell the correct amount of power by watching his arc, and the results from it, as well as by the sound of the arc itself. The length of cables must be taken into consideration also, as there is approximately a 5-volt drop to every 100 ft. of cable.

The correct amount of current cannot be judged at the arc with a carelessly made ground connection. The operator should be sure that his polarity is correct. I have seen a few instances where operators were trying to weld with the negative line attached to the job for his ground wire. If a welder is unable to judge why his metal does not burn in as it should, and the electrode gets red or white hot before half used up, he should get a polarity indicator, which can be purchased, or else make one from an electric light globe.

A polarity indicator may be made of an incandescent bulb by first breaking the lamp filament and then holding the bulb under water and breaking off the tip. With the tip broken the vacuum will cause the water to fill the bulb. If the two wires of a welding circuit be touched to the terminals of the lamp the polarity of the welding leads is readily determined from the fact that the water about the filament in contact with the *negative* side of the line will begin bubbling when current is passed through the bulb.

There are a number of facts which have a great tendency to make any operator get careless. First of all, there are a great many shops that expect first class welds and at the same time do not attempt to furnish the welder the proper material to work with, such as good grades of different size electrodes, good electrode holders, and proper shields with lenses that afford correct protection to the welder's eyes.

The correct size and grade of electrodes are as essential as the correct size and grade of rivets to put in a boiler, yet I have been ordered by different foremen to weld in locomotive boiler patches with just whatever size or grade of wire I happened to have on hand. That is one reason why certain welds have broken and caused damage to property and loss of life.

These weld failures were collected by a certain committee appointed by Government officials, and after further investigation, certain jobs of electric welding were ordered discontinued. On some roads it was profitable to the company both from an economic and safety first standpoint, but on other roads it has been a loss, because certain jobs that were discontinued can be welded safely if the proper material would be furnished a competent operator.

Another thing that the welder cannot be held responsible for is the manner in which jobs are put up to be welded. For instance, I was once ordered to weld in two mud-ring patches in an old locomotive boiler that is now being used for a stationary boiler in the power house. The old side sheets were originally 5/16 in. in thickness. The patches were set in flush, all mud-ring rivets and staybolts were driven up, the sheet and patch were both bevelled to a feather edge at about 120 deg., and between the two edges there was a space varying from ¼ to ½ in. I refused to weld the job unless a new patch was set in correctly and for my refusal the boiler foreman, trying to make me the "goat," ordered the patches out and other patches put on with patch bolts. These same kind of patches that were set up properly have been welded in at this same shop for the past year and not one has broken open.

There is another strong point that tends to make an operator careless, that is being changed from one job to another without completing the first job. In some cases this practice cannot be helped. For an operator to start on a job that would take him three or four hours to complete, and before he is half done be required to start on another so-called emergency job and then perhaps be diverted to another still more urgent job, results in having several jobs started and none completed. In other words, he is getting "nowhere fast." By the time he is ordered back to complete his first job, he won't care whether it is completed right, or just any way, to get it out of the way.

The light from the electric arc being the strongest light known, is extremely injurious to the eyes if not controlled by suitable screens and shields fitted with proper lenses. There are a great many shops that furnish their welders a straight board fitted up with two or three thicknesses of colored pot glass. These different compositions of common glass will not kill the infra-red or ultra-violet rays of light which are invisible to the naked eye, yet are the cause of all the trouble. These injurious rays of light may not affect the eyes immediately, but by the time an operator has had enough experience to qualify him as a good mechanic, if his eyes have not been properly cared for, he will be ready to place his name on the long list of retired half-blind welders.

There are optical companies in both Chicago and New York who manufacture good welding lenses, which should be purchased by the companies, but if a welder cares to play safety first with his own eyes, he will carry his own shield and lenses with him. Getting used to one shield and the same electrode holder has a great deal to do with efficiency.

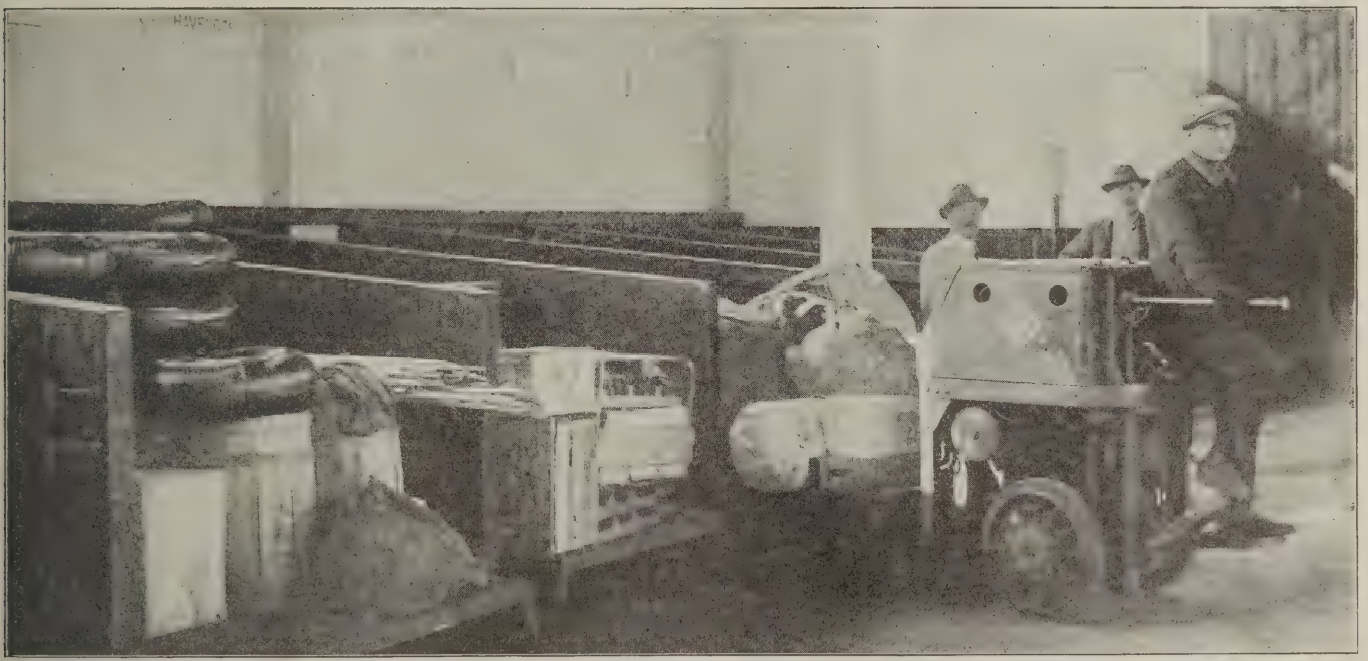
Industrial Trucks in C. P. R. General Store House

Great impetus has been given to the development and extension of the use of electric industrial trucks during the last few years by the rapidly growing cost and shortage of labor. The railroads have shared extensively in this development, particularly in the handling of freight and baggage and in the movement of material about car and locomotive repair shops. The possibilities for the effective use of industrial trucks for the movement of material within the storehouse have been demonstrated clearly in the general storehouse of the Canadian Pacific

Self-Loading Truck with Portable Platform in Use at the General Storehouse of the Canadian Pacific at Montreal, Quebec. As is generally the case, the trucks are used here primarily because of the reduction which they effect in the amount of labor required for the direct movement of material. However, other secondary advantages of importance have attended their use, including a saving in car time, at the general storehouse and a much later distribution of material in making up the daily l.c.l. shipments to local storehouses, which permits a complete classification of these shipments in station order with a consequent increase in the facility of unloading at destination.

About four years ago two Elwell-Parker electric trucks of the self-loading type were placed in service in the Montreal general storehouse and the details of the present system of consolidating and loading daily l.c.l. shipments have been developed to take full advantage of the possibility for economy which trucks of this type possess.

The illustrations convey a clear conception of the methods employed. The bins shown are arranged along the outside wall of the storehouse near the point where the smaller miscellaneous articles are brought together and packed for shipment. Each bin is labeled with the name of the station to which it is exclusively devoted. At the beginning of each day, a ruggedly constructed wood platform suitable for self-loading on the truck is placed by one of the trucks in each of these bins. The truck, accompanied by a stores man, is then used to call at the different sections to secure the material to fill the requisitions and deliver it to the bins, where it is loaded on the platforms instead of being placed on the floor, as was the former practice. One handling of all material shipped has thus been eliminated. Should a shipment require more than the capacity of one platform, another is placed in the bin after the first is loaded.


The Method of Classifying L. C. L. Shipments for Handling with Self-Loading Trucks at the General Storehouse of the Canadian Pacific

Later in the day when the cars have been spotted ready for loading, the trucks are used to pick up the platforms, move them into the cars and leave them. While one platform is being unloaded by the car gang, a truck returns for another, thus eliminating the loss of time by the car gangs while waiting for loads. The loading is thus handled so expeditiously that distribution of material may be continued much later than was possible when using hand trucks, and the loading may be completed with all material in perfect station order. This eliminates the necessity of moving articles loaded out of station order each time the car is opened and greatly facilitates unloading. The later loading made possible by the use of the trucks also effects a material saving in car time.

The self-loading trucks have proved almost equally effective as labor savers in handling incoming material as they have in shipping. When purchased materials are delivered to the stores department by teamsters, they are unloaded from the wagons directly onto truck platforms assigned for that purpose. The loaded platforms are then moved to the proper sections of the storehouse for unloading directly into stock and one handling operation is saved.

The general storehouse at Montreal is located at the Angus shops and a comparatively large amount of stores materials are manufactured in the shops. The self-loading trucks and platforms are used in handling such materials. Empty platforms are placed by the trucks at suitable locations in the shops where completed materials for stores stock are loaded directly onto them. The trucks convey the material on these platforms from the shops to the storehouse, replacing loaded platforms with empty ones.

The saving in time and labor which has followed the adoption of the platform method of loading l.c.l. shipments has led to the development of this scheme one step further in connection with the full carload shipments of miscellaneous stores to a single point. Instead of unloading the material from the platforms when they are placed in the car, as in the practice with l.c.l. shipments, the platforms are left in the car and shipped with the loads on them. When the shipment reaches its destination it is then only necessary to run a truck into the car and carry the loaded platforms out.

PRACTICAL STUNTS

An Air Pressure Spraying Outfit

By M. B. McRee

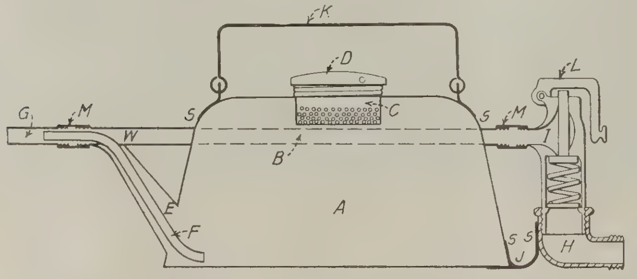
The illustration shows a cross-section view of an air pressure spraying outfit which was made from material carried in practically every railroad storehouse. The device was made with very little trouble and at small cost. The parts required for the construction of the sprayer are given in the list which follows:

Material for Making Sprayer

A—Container made from pressed steel oil can or tallow pot.
B—Piece of ¼-in. iron pipe, 10 in. long, threaded on both ends with slot 3/16 in. wide and ¾ in. long at *W*.
C—Strainer at filling opening below screw cap.
D—Screw cap with air vent in top.
E—Spout of can used as protection of vacuum or suction pipe, and also as support for main pipe and spray nozzle.
F—Suction tube made of ⅛ in. copper tube 5 in. long welded to main pipe at *W*.
G—Nozzle made of ¼ in. pipe 1½ in. long, threaded on one end; detachable for cleaning.
H—Air intake; ¾ in. by ¼ in. street ell.
I—Valve made from faucet from water cooler, threaded on nozzle for a ¼-in. coupling.
J—Brace soldered on container and street ell.
K—Bail for carrying; ears soldered on at *S*.
L—Trigger for pressure valve.
M—Couplings.
S—To be soldered.
W—To be welded.

The container holds about ½ gal. It is a little more than 10½ in. over all.

Excellent results have been obtained with the sprayer on overhauling several motors and generators. After thoroughly cleaning armatures, fields, motors and stators, they were sprayed with No. 1 white shellac. The first spraying was done with a thin mixture and it was found that under fair pressure the shellac was forced into the slots and windings, penetrating to the core in a manner that would have been impossible with the ordinary brush method.



Sketch of Homemade Sprayer

After the first coat dried a heavier or thicker shellac was used, spraying the same as with the first coat, taking care to cover all thoroughly. When dry the second coat presents a heavy glossy finish which is almost impervious to water and dampness. It was also found that dust did not collect in machines finished in this way as the outer surface remains smooth and dry.

Anyone familiar with car lighting generators and coal chute motors knows the conditions under which these machines run—rain, snow, steam, dampness and coal dust. But these windings, if cleaned and sprayed first with shellac, and then with some insulating paint, will give practically no trouble in the future.

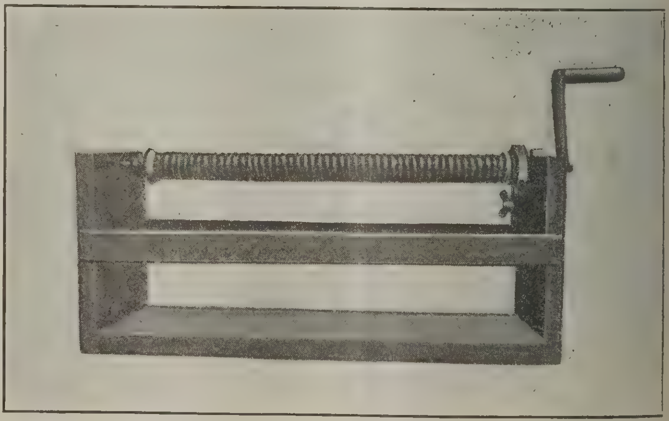
We have found the sprayer to be a time saver in painting car lighting battery boxes, battery trays and tanks, with a thin mixture of asphaltum paint.

Many times brush holders, brass and other copper parts become corroded and dirty, and cleaning is a very slow job. If the sprayer is thoroughly cleaned inside and a very fine grade of sand procured, an excellent sand blast may be found in this homemade device.

A Heater Coil Winder

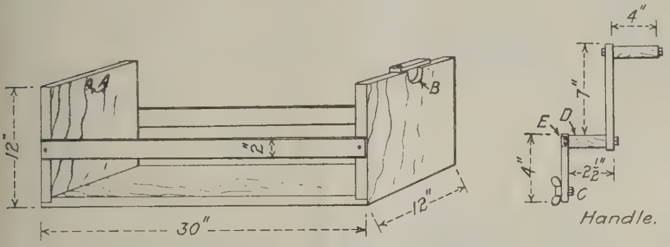
By J. P. Hiltz, Long Island R. R.

The device designed for winding coils used in heating cars by electricity, which is shown in the illustrations, may be made from almost any kind of lumber, but the ends should be preferably at least one inch thick. The measurements given in the sketches should not necessarily be followed unless the coils to be rewound are similar to those for which this device was constructed. Different sizes of heater rods are used on different makes of cars and the coil winders should be made accordingly, allowing ample room for turning.



The Winder Completed

Referring to the illustration, *A* points to a hole with a piece of ⅜-in. pipe run through to act as one bearing for one end of the heater rod; *B* indicates a slot cut in the opposite end of the support to accommodate the *D* part of the handle which acts as the other bearing; *C* is a ⅜-in. wing nut on a 1-in. by ⅜-in. machine bolt, which holds the handle firmly to the heater casting; *E* points to a ⅝-in. square hole cut in the wood and which rests on the center of the heater rod. After the handle has been properly clamped to the heater rod casting, by means of the wing nut, one end of the rod is inserted in the bearing *A* and the handle is dropped into the slot *B*. A small strip of wood is screwed down over this slot so as to hold the handle in. The device is most conveniently operated by two men, one man ties the heater coil and feeds on the wire, while the other man turns the handle. When the coil is wound the other end is secured, and while this is being done the helper, with another handle, prepares another heater rod for winding. While the first part of this second coil is being tied, the helper is taking off the handle from the finished coil.

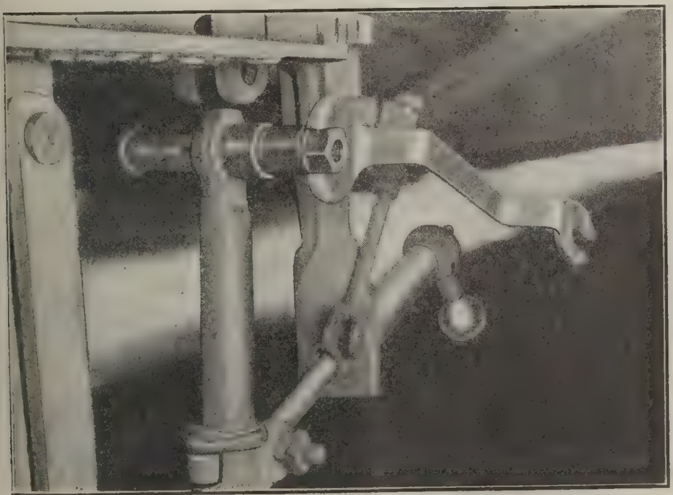


Construction Details of the Winder

A Bushing Remover and Replacer

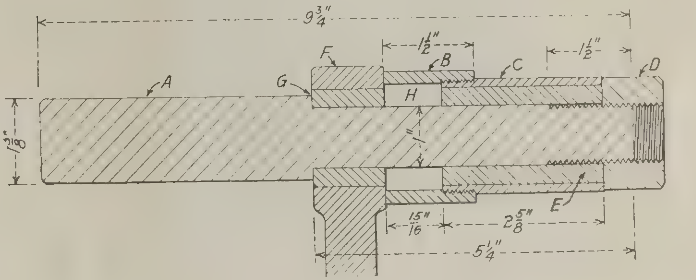
By P. B. Streeper, Electrical Foreman, Terminal Railroad Association, St. Louis, Mo.

The illustrations show a handy device for removing and replacing the bushings in axle generator supports. It will do the work in less than half the time it ordinarily takes when a hammer and driving pin are used. In most cases considerable force is required to remove and replace bushings, and with old method the eye in the U-frame may be damaged during the operation of removing the worn bushing. Any damage to the eye of the U-frame will make it much more difficult to apply the new bushing, which may also be battered or damaged during the process of installation, in which case the supporting pin cannot be inserted.



Showing the Application of the Bushing Remover

This device eliminates all possibility of damage either to the eye of the U-frame or the bushing. It can be made from scrap material or from machined parts if desired. The sketch, however, shows the details of the device assembled from various parts which were picked up in the shop. For instance, the part indicated in the sketch by *A* was cut from the pole changer end of a type G Gould generator armature shaft; *B* is a standard coupling for a 1½-in. pipe; *C* consists of a short piece of 1½-in. pipe, threaded on one end; *D* is an ordinary 1-in. hexagon nut, and *E* consists of two bushings the same as those used in the U-frame of generator supports.



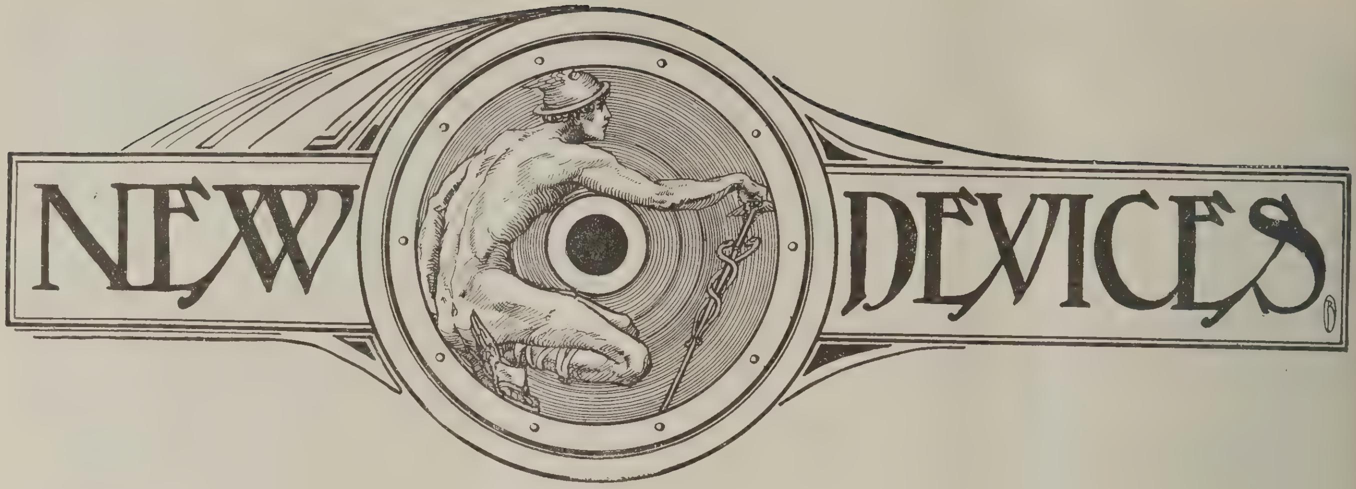
Construction Details of Bushing Tool

It will be observed that the sketch shows the device in position for removing the bushing *G* from the eye of the U-frame *F*. The photographic reproduction illustrates an actual case of removing a worn bushing. Referring again to the sketch, it will be noted that the bushing *G* will be forced in the recess *H*, due to the turning of the nut on the end of the shaft.

In using this device it will be found that the force required to turn the nut is considerably reduced if the opposite end of the shaft is occasionally struck a few blows with a hammer. In some cases it will be necessary to apply a pipe wrench to the shaft in order to prevent it from turning. A new bushing can be inserted in the eye by placing it between the U-frame and the shoulder on the shaft; then proceed in a manner similar to the method previously described for removing a worn bushing.

Taping Formed Coils

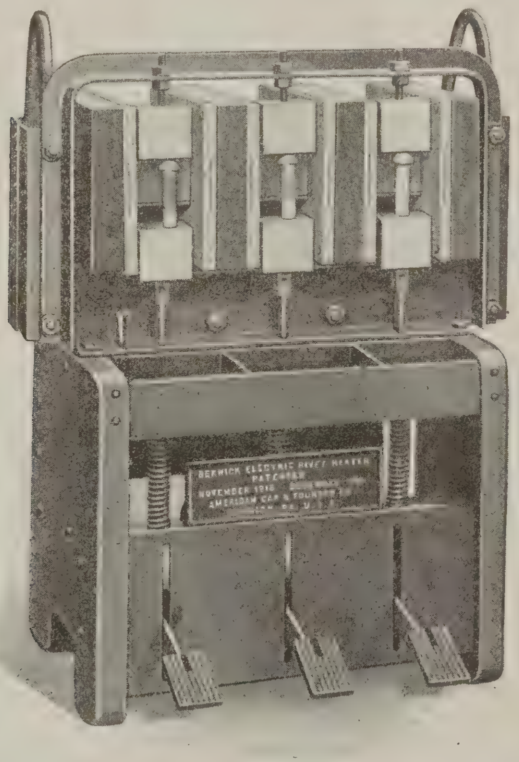
The taping of form wound coils for pole changers, motor fields, etc., if friction tape is used, is somewhat of a tedious task, especially in some instances. On the other hand if high tension tape, or varnished cambric as it is sometimes called, is used the troubles experienced in taping and those that develop in service will likely be removed. This high tension tape is cut on the bias and when drawn over the ends of the coil will not curl at the edges. It can be drawn tighter than most friction tape and will not absorb as much moisture. It also provides better insulation. After one of these coils has been taped with this product it is dipped in medium thick orange shellac, then allowed to dry for a day or two.



NEW DEVICES

Heating Rivets by Electricity

The electric rivet heater shown in the illustration was designed and perfected by the American Car & Foundry Co., during the past six years in order to improve the working conditions in its own shops. Daily use developed so many valuable features that several outsiders, who had seen the heaters in operation, asked that they be marketed. This was done in 1919 and 11 standard Berwick electric rivet heaters, for various rivet sizes and capacity requirements, are listed in the catalogue published recently. It is estimated that a saving of at least 40 cents per 100 lb. of rivets over the old method of heating can be easily effected. The maintenance expense, as indicated by six years of constant use, is too low to be figured.



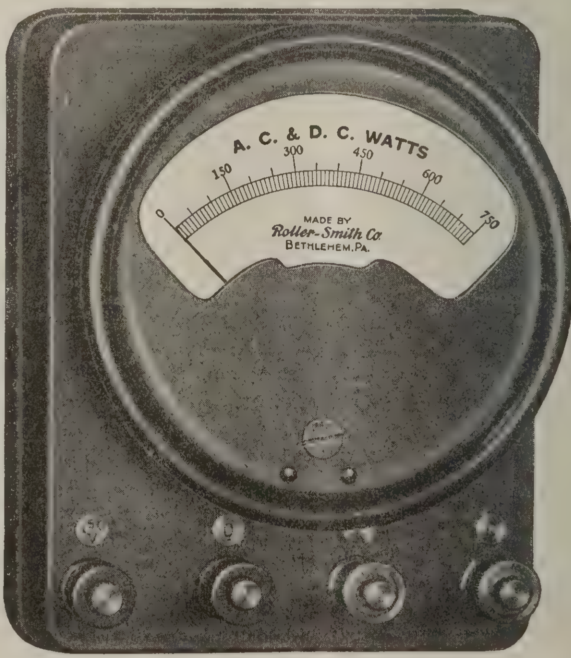
A No. 3. Three-Electrode Berwick Electric Rivet Heater for 5/8 in. to 1 in. Diameter Rivets up to 4½ in. Long. Its Capacity is About 300 Hot Rivets Per Hour

The heater provides hot rivets with great rapidity. From 20 to 30 sec. after the rivet is placed between the electrodes it is heated sufficiently for use. The machine may be placed close to the work, often close enough to eliminate the services of the boy for passing rivets to the riveter.

The current passes evenly through all parts of the rivet and the center and the outside are heated simultaneously. Radiation from the surface to the atmosphere makes the center the hottest part at all times so that when the surface shows a sufficient degree of heat the center is sure to be properly heated also.

Pocket Portable Alternating Current Meters

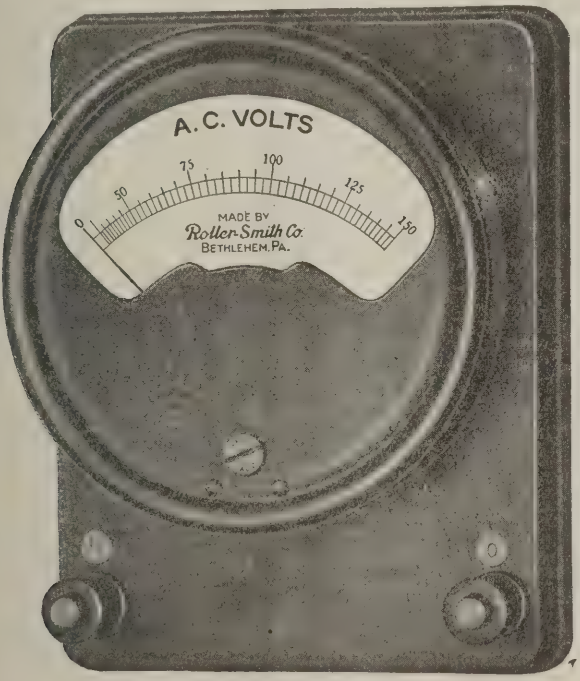
With the rapidly increasing use of alternating current for all kinds of applications there has been a corresponding increase in demand for smaller and less expensive alternating current measuring instruments. In order to meet this demand the Roller-Smith Company has developed and put on the market, a line of small, inexpensive, type HA, alternating current, portable



The A. C. and D. C. Wattmeter

meters, shown in the illustration. These instruments are suitable for general testing of a. c. motor and generator circuits, light and power circuits, etc. They are particularly useful to plant electricians and "trouble shooters." The ammeters of this type range up to and include 50 amperes; the voltmeters as high as 300 volts; and d. c. and single-phase wattmeters with maximum capacities of 30 amperes, 300 volts. The ammeters and wattmeters can be used of course for larger current by means of 5-ampere capacity instruments with external current transformers having suitable ratios of transformation. Practically all of these instruments are so designed that they may be used on direct current also, with good accuracy, this being particularly true of the ammeters and wattmeters.

The mechanism of the ammeters and voltmeters is of the electro-magnet type and of the wattmeters, electrodynamometer type with efficient air damping. The construction is simple and rugged and the entire mechanism is mounted on one base, thus insuring correct alinement of all parts. Jewels are carefully selected Ceylon sapphires; pivots are of hardened steel; the dial is pure white Bristol board; the pointer is light but rigid aluminum and is of the "knife-edge" type, enabling close reading. All of the instruments are 4¼ in. wide and 5¼ in. in length. The voltmeters and ammeters have a depth of 2 in. while the wattmeter has a depth of 3 in.

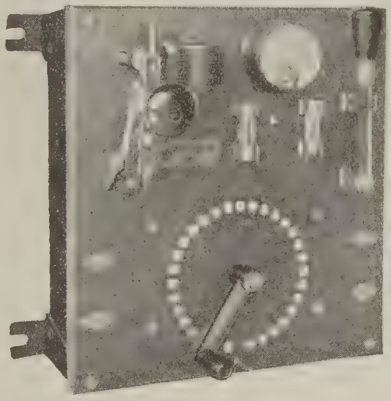


The Pocket Portable Voltmeter

New Rheostat for Charging Batteries on Gasoline Cars

For charging storage batteries used for electric lighting, starting and ignition on gasoline cars, The Cutler-Hammer Mfg. Co. of Milwaukee and New York has developed the new charging equipment shown in the illustration, which is to be used with a direct current source of supply. This charging set consists of a slate panel mounted on a wall type frame and carrying a low-current cutout, single pole main line knife switch and fuses, ammeter, and 30-step rheostat, and is capable of charging any number of cells in series, from 3 up to 42, or the maximum number that can be charged on the voltage of the circuit. The resistor is mounted in the frame back of the panel. The ammeter and knife switch may be omitted if desired, or the 30-step rheostat may be furnished alone or with an ammeter and double pole fused knife switch.

The line lugs are on one side of the panel and the battery lugs on the other side. After line and battery connections are made for charging, the knife switch and low-current cutout are closed in succession, making sure first that the rheostat handle is in the position of "all resistance in." Resistance is then gradually cut out of circuit until the charging current is brought up to the right value, as indicated by the ammeter. Should the line voltage drop low enough during charge to cause the battery to discharge back into the line, the low-current cutout will automatically release, disconnecting the battery from the line.



New Charging Panel has 30-Step Rheostat, Low-Current Cutout, and Ammeter

The charge is terminated by opening the knife switch, which causes the low-current cutout to open, and interrupts both sides of the charging circuit, thus totally disconnecting the battery from the charging source.

Alloy for Bonding Aluminum to Brass and Copper

The Mirete Company of Massachusettes, Inc., Springfield, Mass., has developed a new alloy for bonding aluminum to brass, copper or other metals. The manufacturers say it has a conductivity that approaches 90 per cent that of pure aluminum and that the bond is absolutely permanent. The alloy is called "Mirete" metal and can be used with an ordinary gasoline torch. Its tensile strength as given is as great as that of aluminum itself, with a higher elastic limit.

Exhaustive tests show for it oxidation not so great as aluminum or copper and little evidence of electrolysis. It is claimed that with the use of this alloy the resistance loss at points of connection can be overcome either on aluminum or copper wire so that it is possible for the joint to have as low a resistance or possibly a lower resistance than an equal length of the conductor.

General News Section

The Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has opened an office and warehouse at Jacksonville, Fla.

The National Electric Light Association has selected Pasadena, California, as the convention city for 1920, the date selected being May 18 to 21.

The Transportation Engineering Corporation has moved its Chicago office from the Manhattan building to the Transportation building. K. R. Hare is district manager.

Benjamin Electrical Manufacturing Company, Chicago, Ill., has moved its San Francisco office from 590 Howard Street to 580 Howard Street, occupying the entire four-story building.

The Electric Storage Battery Company, Philadelphia, Pa., announces that on April 24, its New York office, which has been for 22 years at 100 Broadway, will be removed to 23 West Forty-third street, New York.

On April 30, the New York office of the Sunbeam Electric Manufacturing Company (formerly Schroeder Headlight & Generator Co.), Evansville, Indiana, was moved from 50 Church Street to 52 Vanderbilt Avenue, New York City.

Russell P. Askue has severed his connection with the Publicity Department of the National Lamp Works to go into agency work with headquarters at Cleveland, Ohio. Mr. Askue has been with the National Lamp Works for several years, prior to which he was advertising manager for the Ivanhoe-Regent Works of General Electric Company.

L. Brandenburger of Salt Lake City, Utah, recently appointed sales representative for the Cutler-Hammer Manufacturing Company, has changed his quarters from the Walker Bank Building to larger rooms at 59 West Broadway. Mr. Brandenburger's territory includes the state of Utah, the western section of Wyoming and three-fourths of the state of Idaho.

The Roller-Smith Company, 233 Broadway, New York City, announces the removal of its Cleveland office from the Williamson building to the Vickers building, Sixty-fifth street and Euclid avenue. The new offices occupy considerably more space than the old ones. The change was found necessary to take care of rapidly increasing business and larger stock. The Cleveland office will continue to be in charge of J. E. Wood, district manager.

The General Electric Company, Schenectady, N. Y., announces that the new addition to the Windsor works of the General Electric Company will be completed about the first of June and will be ready for occupancy about July 1. The building will be 200 ft. x 70 ft. and will contain two floors and basement, providing 40,000 sq. ft. of floor space. Small electric motors of various horsepowers for direct current are manufactured at the Windsor works.

The Westinghouse Union Battery Company was recently organized in Pittsburgh, Pa., to produce storage batteries for every industry in which batteries are used. The company will specialize in starting and lighting batteries for renewal in automobiles, although the complete line will include batteries for trucks, tractors, motor boats and airplanes; also for home lighting systems, train lighting and railway signals. **A. L. Humphrey,** president of the Westinghouse Air Brake Company, and active in the management of all of its subsidiary organizations, is chairman of the board of directors of the new company. **D. F. Crawford,** vice-president and general manager of the Locomotive Stoker Company, is president of the new company, and **T. R. Cook,** formerly chief engineer and general production manager of the Willard Storage Battery Company, is vice-president and general manager. **T. S. Grubbs,** vice-president of the Union Switch & Signal Company, is also vice-president and secretary and treasurer of the new organization. The company is now occupying three floors of the Union Switch & Signal Company's factory at Pittsburgh. Its initial production will be from 1,200 to 1,500 batteries a day and the employees to start with will number about 500. It was decided to occupy the present working quarters instead of building a new factory at once, in order to lose no time in starting production. Preparations have been made to build a factory of from two to three times their present capacity on adjoining property. The company expects production to be started in June.

Hydro-Electric Development in Japan Is Limited

Although there has been rapid advance in hydro-electric development in Japan since the many natural sources of power have been located, there seems to be no prospect that she will ever rival Sweden in thus compensating for her deficient coal supply.

First, are the government regulations, which limit a concession among other things to 30 years, with possible confiscation at the end, and prospects of all sorts of novel restrictions in the future, against which the company is forbidden to protest.

Second, there is the rapidly advancing cost of operation, which includes taxation. The business tax is .45 per cent on the gross receipts, the income tax 9.47 per cent of the same, and the director's bonuses and reserve, which must be taken out before the shares pay dividend, are about 15 per cent. In other words, one fourth of the gross receipts must be deducted in addition to the operating expenses before a net profit can be shown.

Third, is the very great cost today of installation, due to the advances in materials, machinery and labor. The older companies installed their plants at a cost of about 250 yen per h.p., while a company who are now putting up a plant are paying 800 to 1,000 yen per h.p. A transmission line costs 50,000 to 60,000 yen per mile, and the market for current (Tokyo or Osaka) is a long way from the source of supply. Although many new companies are being floated, the big companies already established are in process of coalescence into a trust or amalgamation, in order to continue to do business at a profit.

Fourth, the climatic factor is a barrier. The streams are all short, with a seasonal flood and low water stages, and no storage reservoirs. A plant must be built either to take care of the minimum flow, in which case the cost of installation and operation may be too great to show profit, or else it must be built to take care of the average flow, with the difficulty of selling current which may be shut off from time to time.

Western Electric Company

The annual report of the Western Electric Company, New York City, for the year ended December 31, 1919, shows net profits, after all charges and federal taxes, of $4,388,909, equivalent, after preferred dividends, to $17.25 a share on the 150,000 shares of common stock of no par value. Dividends of $10 a share were paid on the common stock, and the balance for that stock was $1,088,909. Due to the cessation of the war, sales to the government in 1919 weer about $16,000,000 less than in 1918, but the increase in other balances largely offset this loss, report states, and total sales for 1919 were but $9,500,0000 than in 1918. The income account is as follows:

Sales	$135,732,489
Other Income	854,570
Less—	
Cost of merchandise	118,420,440
Expenses	10,986,139
Taxes	1,578,399
Interest	1,263,180
Dividends	3,300,000
Balance for common stock	$1,088,909

Unit Cost of Canadian Water Power Development

The Dominion Water Power Branch, Department of the Interior and the Dominion Bureau of Statistics, Department of Trade and Commerce, have through co-operation just completed an exhaustive census and analysis of the developed water power in Canada. The figures are complete to January 1, 1920.

There is installed throughout the Dominion 2,418,000 turbine or water wheel horsepower of which 2,215,000 hp. is regularly employed in useful work. The larger figure includes the total installed capacity at full gate opening. It includes reserve units but not exciter units. The ultimate capacity of these plants, together with that of new plants now under construction is 3,385,000 hp. It is estimated that the undeveloped waterpower amounts to 19,554,000 hp.

The total installed water wheel and turbine horsepower in hydro central electric stations is 1,756,791 hp. Fuel auxiliaries installed as stand-bys to these hydro stations brings the total installed primary capacity up to 1,873,989 hp., connected to 1,449,180 kva. dynamo capacity. The total capital invested in these central stations, inclusive of transmission and distribution systems, is $369,464,961 or an average of $210 per installed primary horsepower.

Of special interest to engineers is the actual cost of construction of hydro-electric power stations, exclusive of transmission and distribution systems. The figures of 70 representative hydro-electric stations throughout the Dominion with an aggregate turbine installation of 745,797 horsepower show a total construction cost of $50,740,468 (pre-war figures) or an average of $69.11 per installed horsepower. This cost includes the capital invested in construction of dams, flumes, penstocks, and all hydraulic works, and of power stations and equipment. It includes real estate and transmission and distribution equipment. The figure in brief represents the capital cost of construction at the power site.

A. R. E. E. To Meet at Atlantic City

The semi-annual meeting of the Association of Railway Electrical Engineers will be held at the Hotel Dennis, Atlantic City, on June 14. The meeting will be called to order at 9 a. m. Progress reports will be presented by the following committees: the committee on trucks and tractors; committee on electric welding; committee on illumination; committee on train lighting equipment and practice; committee on railway stationary power plants; committee on electric head lights; committee on electrification; committee on electric repair shop facilities and equipment.

Committee to Investigate Electrification

A committee has been formed in the Ministry of Transport to investigate the electrification of English railways. It is formed with Sir Alexander Kennedy, consulting electrical engineer, as chairman, with the following as other members:

Sir John A. F. Aspinal, consulting mechanical engineer to the ministry of transport.
A. R. Cooper, electrical engineer of district railway.
Sir Alexander Gibb, K. B. E., C. B., director general of civil engineering, ministry of transport.
Philip Dawson, consulting engineer.
C. H. Merz, consulting engineer.
Sir Philip Nash, K. C. M. G., C. B., ministry of transport.
Sir John Snell, chairman of the committee under the electricity supply bill.
Roger T. Smith, electrical engineer of the Great Western, and president of the Institute of Electrical Engineers.
Sir Henry Thornton, representing the Railway Companies' Association, secretary.
Major Redmond.

The terms of reference to the committee are:

That the committee should report on:

(1) Whether any regulation should be made for the purpose of ensuring that the future electrification of railways in this country is carried out to the best advantage in regard to interchange of electric locomotives and rolling stock, uniformity of equipment, and other matters.

(2) If any such regulations are desirable, what matters should be dealt with and what regulations should be made.

(3) How far it is desirable, if at all, that railways or sections of railways already electrified should be altered so that they may form parts of a unified system.

Mechanical Section Scholarships

Two of the four scholarships at Stevens Institute of Technology, which the Mechanical Section of the American Railroad Association offers to sons of members of the section, will be vacant in June. These scholarships cover the regular tuition charges for a four-year course, leading to the degree of mechanical engineer. The course offered also includes instruction in electrical, civil and other branches of engineering. Applications should be in the hands of V. R. Hawthorne, secretary, Chicago, not later than June 15. In case there are more than two applicants the scholarships will be given to the two passing the entrance examination with the highest standing. Full information will be supplied by the secretary upon application.

PERSONALS

Calvert Townley, assistant to president of the Westinghouse Electric & Manufacturing Company and president of the American Institute of Electrical Engineers, has been re-elected vice-president of the United Engineering Society.

Paul R. Duffey, formerly supervisor of power plants of Potomac District, United States Railroad Administration, with offices at Hagerstown, Md., has been appointed chief inspector of motive power, maintenance of equipment department, Western Maryland Railroad, with headquarters at Hagerstown, Md. Mr. Duffey will also be supervising officer of all power plants on the Western Maryland system and subsidiary lines. Mr. Duffey entered on his new duties March 1.

Daniel Joseph Brumley, has been appointed chief engineer Chicago Terminal Improvement of the IIinois Central, with headquarters at Chicago. Mr. Brumley was born near Belmore, Ohio, on March 19, 1865. He graduated from the civil engineering school at Ohio State University in 1895 and entered railway service as assistant section foreman on the Louisville & Nashville in June of that year. During the latter part of 1896 he became assistant engineer for the Columbus & Hocking Coal & Iron Co., at Straitsville, Ohio. The following two years he was successively assistant supervisor on the Louisville & Nashville at Belleville, section foreman at Evansville, Ind., rodman at Louisville, Ky., and assistant engineer at Clarksville, Tenn. He was transferred to the chief engineer's office at Louisville, Ky., in 1898 and in September, 1901, he left the Louisville & Nashville, being appointed roadmaster of the Mexican National with headquarters at Laredo, Texas. He returned to the former road one month later where he remained until October, 1904, when he was appointed division engineer of the Indianapolis Southern, now part of the Illinois Central, at Indianapolis, Ind. In March, 1905, he became principal assistant engineer of the Illinois Central, the Yazoo & Mississippi Valley and the Indianapolis Southern, with headquarters at Chicago. Mr. Brumley was engineer of construction of these two roads from June, 1910, to April, 1913, when he was appointed engineer maintenance of way. In November, 1913, he was promoted to assistant chief engineer, with headquarters at Chicago, and in April, 1914, he became valuation engineer, which position he held until his appointment as chief engineer of the corporation in 1918.

D. J. Brumley

L. W. Strong, formerly of the publicity department of the Westinghouse Air Brake Company, has been appointed director of research engineering.

William N. Keiser has been appointed manager of the general construction equipment department of the **Lakewood Engineering Company,** Cleveland, Ohio. Mr. Keiser was born near Logansport, Ind., and served in the Spanish-American war. He graduated from Purdue University with the degree of electrical engineer. He began work with the General Electric Company, for whom he built power houses and underground systems, and then served with a public utility company as chief electrical engineer. Subsequently he was sales manager of the Parsons Company, Newton, Iowa, and then was with the Hydraulic Steelcraft Company, Cleveland, until his appointment as manager with the Lakewood Engineering Company, as above noted.

W. N. Keiser

Godfrey H. Atkin has been appointed manager of the western district of the Electric Storage Battery Company, covering the sales offices, warehouses, service stations and all departments in Chicago, St. Louis, Kansas City, Minneapolis and Denver, with headquarters in the Marquette Building, Chicago. Taliaferro Milton is in charge of the Chicago office, succeeding Mr. Atkin. Both appointments were effective March 1.

Hammond D. Baker has been appointed manager of the Detroit, Mich., office of the Roller-Smith Company, New York, with office at 1202 Majestic Building. Mr. Baker, a graduate electrical engineer of Alabama Polytechnic Institute, after his discharge from the aviation service of the army, became connected with the United Motors Corporation as technical traveling representative. Later he joined the sales department of the Hoskins Manufacturing Company, Detroit, Mich., from which he resigned to accept the appointment with the Roller-Smith Company.

D. H. Colcord has been appointed advertising manager of the **Square D Company,** manufacturers of safety switches, Detroit, Michigan, and Walkerville, Canada. Prior to this change he served in the capacity of director of research engineering.

Mr. Colcord came to the Square D Company from the publicity department of the Westinghouse Air Brake Company; prior to this he was associated with the department of publicity of the Westinghouse Electric Company, Pittsburgh. Mr. Colcord is known for his contributions to technical and scientific journals and popular magazines.

J. C. Sweeny, chief of electrical department of the Lake Erie & Western Railroad at Lima, O., has resigned to engage in general electrical contracting business.

J. L. Ray, manager at Pittsburgh, Pa., of the **Western Electric Company,** New York, has been appointed power apparatus sales manager in the general sales department, New York, and **W. H. MacCrellish** has been appointed manager at Pittsburgh, to succeed Mr. Ray.

W. H. Patterson, manager, resale section, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. has been appointed assistant-to-manager, Industrial Department in charge of metal working and wood working industries. Mr. Patterson graduated from the electrical engineering course of Purdue University in 1905. The following January 1906, Mr. Patterson entered the apprenticeship course of the Westinghouse Company. In 1910 he was made manager of the resale section. Mr. Patterson has been prominently identified for a number of years with the development of motors and control apparatus for application to cranes, elevators, hoists, and machine tools. During the war he served on the United States Shipping Board, Emergency Fleet Corporation, Electric Welding Committee. When the American Welding Society was formed about a year ago, he was elected a director. Mr. Patterson is also a member of the American Institute of Electrical Engineers, National Electric Light Association, Pennsylvania Electric Association, American Society of Refrigeration Engineers, and Association of Railway Electrical Engineers.

OBITUARY

C. W. Johnson

Charles W. Johnson, assistant director of engineering for the **Westinghouse Electric & Manufacturing Company,** East Pittsburgh, Pa., died of double pneumonia on April 21, following an illness of only a few days. He was born on June 30, 1874, and graduated from the Ohio State University in 1896. He then entered the employ of the Steel Motor Company, Johnstown, Pa. Later he became superintendent of the Allis-Chalmers Bullock Company, of Cincinnati, Ohio. In 1907, he entered the employ of the Westinghouse Electric & Manufacturing Company, and was soon appointed chief inspector. In 1912 he became general superintendent of the East Pittsburgh works and in the early part of 1919 was made assistant manager of works. On January 1, 1920, he was appointed assistant director of engineering. Mr. Johnson was a member of the American Society of Mechanical Engineers, the American Institute of Mining Engineers, and the Engineering Society of Western Pennsylvania.

T. N. Vail

Theodore N. Vail, who has been president of the American Telephone & Telegraph Co., since 1907, died on April 16, at the Johns-Hopkins Hospital, Baltimore, Md. Mr. Vail was born in Carroll county, Ohio, July 16, 1845. His early education was acquired at the Morristown Academy, Morristown, N. J. Later he attended Harvard University and the University of Vermont. In 1873, he became assistant superintendent of the railway mail service at Washington and was advanced to the position of general superintendent, which place he held from 1875 to 1878. Shortly after Alexander Graham Bell invented the telephone Mr. Vail became deeply interested in this project and for the greater part of his life he has been identified with the progress of telephone service. The application of telephones became so extensive that the open wire, pole line construction grew to be exceedingly congested in the large cities and considerable thought was given to the suggestions of a proposition of placing the conductors underground. In 1882, at Attleboro, Mass., Mr. Vail, then connected with the telephone industry, instituted a series of experiments to find out exactly what could be done and what could not be done by way of burying telephone wires underground. The first attempt to place the wires underground was made alongside a 5-mile stretch of railroad track and a locomotive was used in connection with a plow for the construction of a suitable trench. Wire, with practically every kind of known covering, was placed in this trench and covered over. This underground construction met with somewhat indifferent success, but was far from satisfactory. In 1885, Mr. Vail was again instrumental in starting a series of investigations with the end in view of developing a satisfactory means of placing telephone wires underground. The present lead covered paper insulated cable, which has become so common today, is the outgrowth of this second series of experiments. Although the greatest part of Mr. Vail's life has been devoted to the telephone industry, there was one period when he gave up participation in this business and became interested in railways and electrical enterprises in Europe and South America. He inaugurated the street railway systems in Buenos Aires and developed power transmission service in neighboring states. Later on when these enterprises had been carried to a high degree of success he disposed of his interest in South American and European countries and returned to the telephone industry in the United States.

Mr. Vail was a member of the National Geographical Society, the American Institute of Electrical Engineers, and many other organizations which are both national and international in their scope.

TRADE PUBLICATIONS

The Lapp Insulator Company, Le Roy, N. Y., has issued bulletin No. 62, comparing designs of American and European high voltage pin-type porcelain insulators. Curves are included.

Appleton Electric Co., 218 North Jefferson St., Chicago, Ill., has just issued supplementary bulletin 8-A, containing 44 pages, in which are listed numerous additions to the line of Unilets and Appleton products. This bulletin has been issued in two sizes—large, and concenient pocket size.

C-H Electric Soldering Irons is the title of a new 4-page, 8½ in. by 11 in. leaflet printed by the Cutler-Hammer Manufacturing Company, Milwaukee and New York. It is known as booklet H. This publication describes and illustrates the C-H soldering irons and associated equipment.

The National Carbon Company, Inc., has issued a new brush bulletin No. 13. This bulletin discusses the troubles encountered in field and armature coils and makes suggestions for their detection and remedies. It also treats of short circuits, open circuits and grounds and the manifestations of these faults at the brushes.

The Standard Underground Cable Company have gotten out their bulletin No. 100-1 describing their products manufactured under the heading copper, brass, tubes, rods, and wires. This booklet gives considerable engineering information of interest to wire users, arranged in tabular form, also the various sizes of tubes, pipes and wires ordinarily supplied.

The Page Steel & Wire Company, 30 Church Street, New York, has published a pamphlet describing fully the electrical and physical properties of American ingot iron wire. This is the first complete publication of this data and the result of many tests made during the past two years under the supervision of the Electrical Testing Laboratory, New York, and Frank F. Fowle, consulting electrical engineer for this company.

The Esterline Company, Indianapolis, Ind., has recently issued a new bulletin No. 395 covering power factor recording instruments. The bulletin points out the evils of low power factor in the central station, at the isolated plant and to the power customer, as well as how to locate and eliminate the causes of low power factor. This booklet will be forwarded to any engineer interested in power factor problems or in the economical generation and distribution of power.

Engberg's Electric & Mechanical Works, St. Joseph, Mo., is distributing its catalogue No. 103. The booklet is 9 in. by 12 in. in size and contains 32 pages. The subject matter is devoted to the description of the product of the Engberg company, which is direct current generating sets from one to 50 kilowatts. The pages are well illustrated with numerous photographs and drawings showing all of the various parts of both engines and generator.

The Benjamin Electric Manufacturing Company, Chicago, Ill., has recently issued its catalogue No. 22. The catalogue is divided into a number of sections and the subjects covered are wireless clusters, plug clusters, industrial lighting equipment, wiring devices, fixtures and fixture parts, industrial signals, and panel boards. Each of the several sections is well illustrated with photographs and line drawings. List prices also accompany the description of the material.

The Hazard Manufacturing Company, Wilkes-Barre, Pa., has recently issued a small illustrated booklet of 16 pages, entitled "Rubber Insulated Wire." The booklet presents a general description of the manufacture of rubber insulated wire, written in interesting style, with emphasis laid upon the influence of thorough mixing and proper vulcanization on the life of rubber insulation, and the necessity of skill and experience in making wire that will stand up under severe working conditions.

The Electrolabs Company, Pittsburgh, Pa., is distributing an 18-page catalogue which illustrates and describes the Oxy-Hydrogen cells which it manufactures. The oxy-hydrogen cells were designed for the purpose of securing oxygen and hydrogen gas of great purity by means of an electrolytic process. The pamphlet describes the method of connecting a number of these cells so that quantities of these gases may be secured for various industrial purposes. A number of photographs showing batteries of the cells are included.

Edison Storage Battery Company, Orange, N. J., has recently issued the third number of its house organ "The Grid." This is a quarterly publication. Most of the articles contained in the April number suggest the use of Edison storage batteries for various purposes. The articles for the most part are unusually instructive and interesting and perhaps the one that ranks first in this respect is entitled "Old King Cole" by Floyd W. Parsons, formerly editor of "Coal Age." The application of electric storage batteries to industrial trucks and other electrical vehicles is described at length and numerous photographs are shown illustrating the use of storage batteries for both motive power and illumination purposes.

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has compiled its annual catalogue of electrical supplies for 1920, which is complete in every detail. The company states that it has been the endeavor to make this book a compilation of valuable engineering and technical data on all electrical supplies and will appreciate any suggestions that will help make the 1921 edition of even greater service than the present edition. Many new lines of apparatus and features are included in the 1920 edition, among which are a line of outdoor switching, lightning-arrester and sub-station equipment; the high-grade miniature switchboard instruments; an electrostatic glow meter; a new line of type M portable graphic instruments; new transmission-line fittings; railway-car equipment; a six-pound iron; electric range; a complete line of standardized electric ovens, and the like.

Railway Electrical Engineer

Volume 11 June, 1920 Number 6

CAR LIGHTING MEN—ATTENTION

Those who have been constant readers of the *Railway Electrical Engineer* have grown familiar with our custom of publishing educational articles in serial form. Most of these articles have been general in their scope, dealing with the theory of electricity and with apparatus which for the most part could be used in numerous practical applications of electric power. There is one application of electricity, however, on steam railroads, which is so exclusively a railroad development that it demands more specific treatment. This application is the lighting of cars by electricity.

The older men who have been engaged in car lighting work for a number of years are fairly well acquainted with most of the tricks that car lighting equipment is capable of playing. The knowledge that most of them have has come from the hard school of experience and by many hours of diligent study. How greatly these men would have welcomed special information bearing on their particular problems.

Car lighting by electricity has passed through its various stages of development, and while its ultimate goal may not have been reached, it is nevertheless a fact that much of the work performed in the operation and maintenance of car lighting equipment has been standardized. There is more information available from the manufacturers of car lighting equipment today than there once was, but unfortunately it is not always presented in such a way as to be of the greatest use.

We have felt for some time that there was a pressing need for information relative to car lighting work which could be readily understood by the men who need it most. With this thought in mind we have arranged to present a series of articles on car lighting work. The task of preparing these articles has been undertaken by a man who has had years of experience in this field and whose ability to write upon this subject has been forcefully demonstrated in numerous articles which have appeared on the pages of the *Railway Electrical Engineer.* This man is Charles W. T. Stuart of the Pennsylvania Railroad. We have every reason to believe that Mr. Stuart will give us a series of articles on this subject that will be bigger and better than anything of the kind that has been presented before. The series will be written upon the assumption that the basic principles of electricity are understood and much space that might be devoted to a long discussion of elementary electricity will be used in presenting the real meat of the subject.

There will be a big demand for these articles. In view of the shortage of paper we will only be able to supply copies of the *Railway Electrical Engineer* to those who are regular subscribers, and requests for back numbers after the series has been started will probably result in disappointment. It is earnestly requested, therefore, that those who read this notice bring it to the attention of others who will be interested but who may not see it.

ELECTRIC HEADLIGHTS BY JULY FIRST

The nearer we get to July 1, the more apparent it becomes that it will not be possible for all of the railroads to equip all of their locomotives with electric headlights by that date, which is the time that has been set by the Interstate Commerce Commission when all motive power should be supplied with this apparatus. There are undoubtedly a number of reasons for this, one of which is the tardiness of some of the roads to order their headlight equipment far enough in advance to insure its prompt delivery. It is also quite certain that some of the roads would never have adopted the electric headlight equipment at all had it not been for the Interstate Commerce Commission ruling to the contrary. It is quite natural that roads which have been content to use the old methods should not be over-zealous or over-enthusiastic with the more modern equipment and it will be these roads, of course, which will not be able to report one hundred per cent completed installations on July 1.

There is no question but that the ruling of the Interstate Commerce Commission was a tremendous stimulant to the electric headlight industry and various types of headlight equipment have been introduced on the market during the past two years. The increased activities in this line have resulted in introducing a number of excellent turbo-generators for headlight service. These equipments have been of the direct current variety, except one which has the distinction of being the only alternating current headlight equipment on the market.

That the electrical equipment on the locomotive has certain peculiar advantages is obvious. Not only is more light available in the cab when needed, but the electric system lends itself to a number of advantages, such as the use of an extension cord and light in making inspection of locomotive parts. Furthermore, the light can be turned on and off with ease. These are, of course, incidental to the real advantages of the electric headlight as compared with other methods of illumination.

The fact that all of the railroads will be compelled to use electric headlights will necessarily bring about a large number of systems of cab wiring. It would be unreasonable to suppose that any two roads would develop exactly the same ideas in their methods of wiring the cabs and the headlights. There are, of course, certain general principles that apply to all of them, but it is certain that they will differ considerably in detail.

While the electric headlight situation is today a live question the indications are that in the future it will become very much more standardized and there is no doubt but that eventually through the efforts of the Electric Headlight Committees of the Association of Railway Electrical Engineers the systems on the various roads will be reduced to a minimum.

THE FALL IN PRICES

The general drop in prices which has spread over the entire United States during the past few weeks came somewhat unexpectedly in spite of the fact that it had been predicted in practically every publication in the country. As a matter of fact the reaction set in a little sooner than was anticipated, although for months it has been brewing, and the present slump was inevitable. It would be too much to expect that all prices will descend in any such manner as has been witnessed recently, because for the most part the more drastic reductions have been in connection with articles that must be classified as luxuries. Nevertheless, when the tendency is downward other commodities are bound to be affected and eventually all merchandise will arrive at a lower level.

Immediately there is opened up the question of the ultimate effect upon wages, for prices and wages are just as certainly bound together as any two things affecting human beings could possibly be. The recent drop in prices came as a relief to the great mass of workers who have not had their incomes increased in anything like the proportion that their expenses have grown. This group is certain to be ultimately the most benefited by a reduction in prices, for since they have not been living on inflated incomes the lowering process cannot affect their earnings. In the long run they are certain to be the best off, financially.

On the other hand, hourly workers in various industries are almost certain to meet with a reduction in hourly rate. The outrageous levels to which prices of commodities have soared have been partly due at least to the exceedingly high wages paid to labor. It is not to be expected that the workmen who have been receiving these high wages will submit without a protest, but the protest will be futile, for high wages and low prices cannot possibly exist at one and the same time. It is very likely that the painful operation of wage reduction will be accompanied by numerous strikes, but in the end they will have accomplished nothing, for the inexorable law of supply and demand cannot be set aside.

However, this condition is not as bad as it might at first seem, for if wages are lowered so will prices be, and in the final analysis labor will be relatively well off, considering the lowered cost of living. It will be very difficult for the average workman to reconcile himself to these conditions, and dissension and bitterness will probably be found on all sides. Fortunately, the ultimate low level of both prices and wages is yet afar off. The drastic reductions which we have recently witnessed simply announce that the peak of high prices has been passed and that from now on adjustments will be made gradually, and it is hoped—painlessly.

THE FUTURE OF ELECTRIC TRACTION

The subject of electrifying steam railroads is tremendous in its magnitude. The ramifications of its effects are too far reaching to be open to any casual observation, but its bearing upon the future transportation problems of this country are growing more obvious each day.

While the entire electrification of all mileage is unquestionably a long way off, it is equally certain that each succeeding year will see an increase in electrical operation. The outstanding success of those roads that have already adopted electric traction completely or in part is a powerful argument that cannot be refuted in favor of this motive power. Of nineteen roads now operating electrified zones nothing is heard but commendation and complete satisfaction with the service. Nineteen railroads have not exhausted the possibilities of electrification by far. The experimental period of electric traction may safely be considered as having been passed, and money invested in the future in this field will be spent with the full knowledge of what can be definitely counted upon in the way of return.

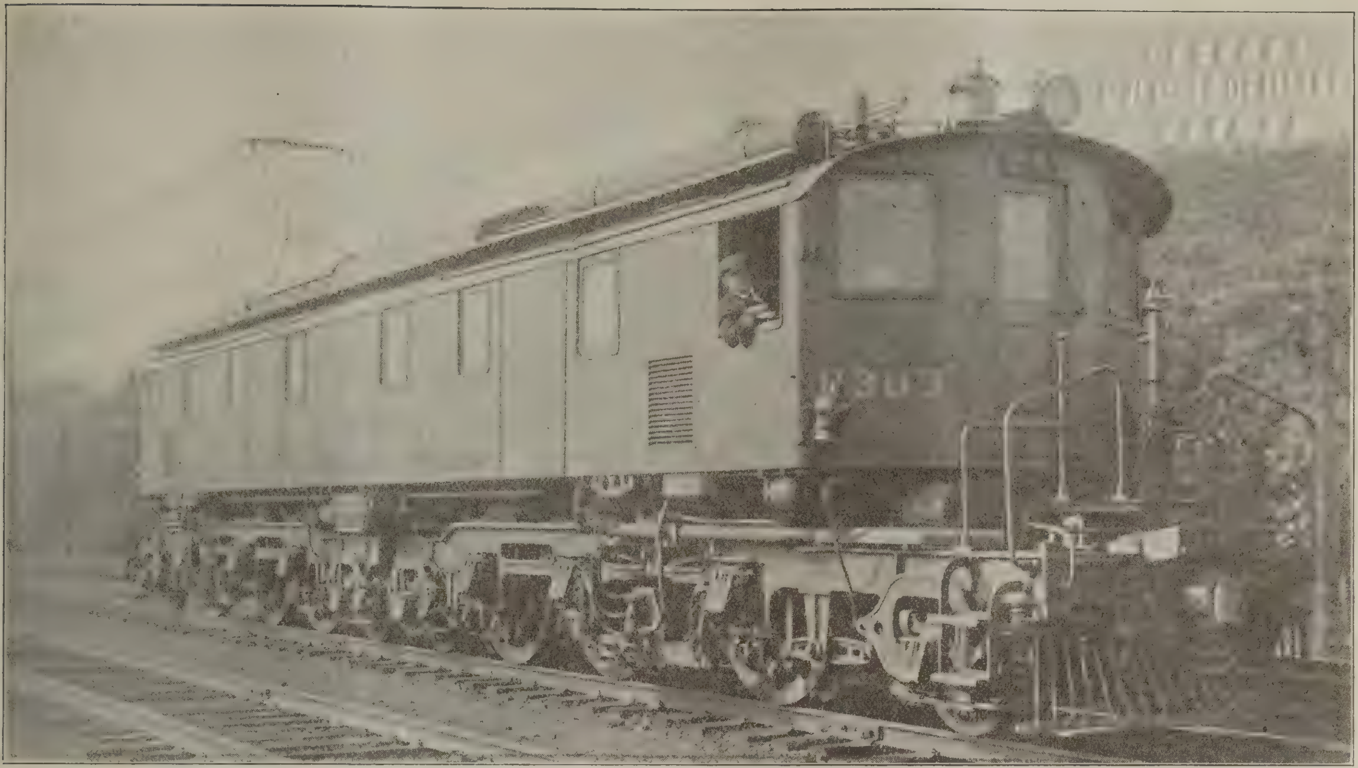
Perhaps the largest electrification project that is being planned at present is that of the Illinois Central, but there are others under advisement. For a long time the Delaware, Lackawanna & Western has been considering the electrification of portions of its road in the metropolitan suburban section. The Pennsylvania expects to use electric power over the mountain grade near Altoona and for months has had a specially designed locomotive under test on the electrified section of line between Philadelphia and Paoli. The significant feature about this latter case is the fact that the locomotive was constructed to operate on an 11,000-volt trolley system, indicating a tendency to favor this construction.

The truth is that the surface of electrification possibilities has scarcely been scratched and the next ten years will witness tremendous growth in this field, including some installations which, if made today, would not be considered practical.

NEW BOOKS

Electric Locomotive Headlight Handbook. Published by the Association of Railway Electrical Engineers, Chicago, Ill. 234 Pages.

"The Electric Locomotive Headlight Handbook," which was discussed at the last annual convention of the Association of Railway Electrical Engineers, has recently been published by that organization. It is paper covered and in every way similar to the book issued by the same organization on the subject of car lighting about a year ago. Eight different manufacturers of headlight equipments have described and illustrated in detail all of the various parts of their equipment. At the beginning of each section devoted to each headlight manufacturer is an index stating specifically where information relative to any certain part of the apparatus may be found. Several pages in the latter part of the book are devoted to questions and answers on general installation and care.



New Haven Electric Passenger Locomotives

Alternating or Direct Current, Overhead Trolley or Third Rail Can Be Used By These Flexible Units

By F. W. Carter
Heavy Traction Railway Dep't. Westinghouse Elec. & Mfg. Co.

THE electrification of the passenger tracks of the New York Connecting railroad over the Hell Gate route has made possible more extensive utilization of the electric locomotives of the New York, New Haven & Hartford Railroad. Through trains may be operated into the Pennsylvania Station in New York from New Haven without changing engines. This electrification has been carried out by the single-phase, overhead catenary trolley system with the same operating characteristics as those employed on the New Haven road, the energy delivered being at 11,000 volts and 25 cycles. The 900-ton express trains and 420-ton local trains are hauled over this route by five Westinghouse 180-ton locomotives which are built for service on either direct or alternating current. They are capable of operating through the East River tunnels, which are equipped with third rail, into the Pennsylvania Station, the change from overhead to third-rail operation being effected at the east end of Sunnyside Yard.

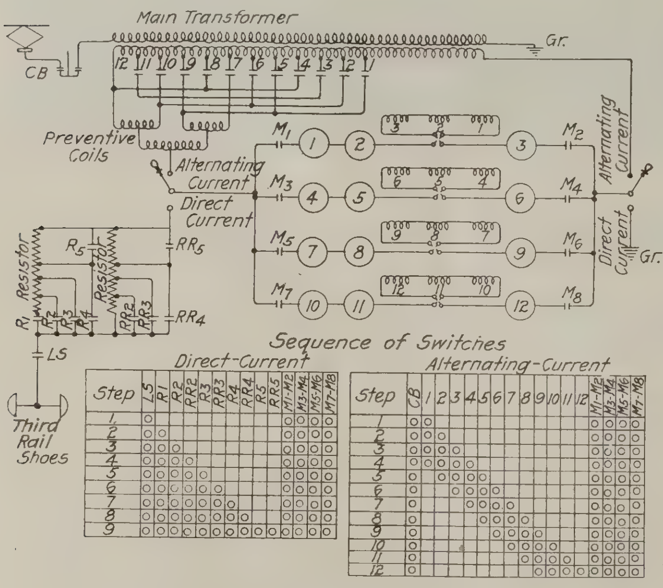
Each of these five locomotives comprises two complete truck units, above which a single steel cab is superimposed. The cab extends the entire length of the two coupled units and is mounted on a suitable frame which is spring supported on the main unit frames. Thus the center of gravity is kept at a reasonable height above the rails, and a maximum proportion of the weight is spring supported, as in steam locomotive practice.

By means of a wrought-iron draw-bar between the main unit frames, no longitudinal play is allowed between frames. A slight amount of vertical play is provided between draw-bar and pockets to take care of track irregularities. The wheel arrangement of each of these main trucks is 2-6-2, and the wheel base of each main unit is 26 ft. 9 in. with a rigid wheelbase of 14 ft. 3 in. No difficulty is experienced in traversing curves of 24 degrees. A pony truck of the Rushton type is placed at each end of a unit. These leading and trailing trucks are provided with heart-links which insure steady riding, and are side equalized with the main truck equalization system. The leading pony truck is side-equalized with the first two pairs of driving wheels, and the trailing pony truck, under the center of the locomotive, is equalized with the third pair of driving wheels. This arrangement obtains in both units.

The cab frame consists of a light, rigid structure built of steel plates, and is spring supported at six points on each pair of main unit frames. The cab-carrying springs are of the coil type, four coils to a support, and are open for inspection and renewal. By means of shims, the surfaces of the cab supports are adjustable in height to give a correct distribution of weight on the main frames.

The cab is held in alinement with the main unit frames by two center-pins which are placed 37 ft. 6 in. apart. The distance between these pins must necessarily be constant, while the distance between the unit centers changes somewhat as the two sets of main frames assume an angular position on curves. To provide for this the center pins are allowed a limited amount of longitudinal movement relative to the corresponding unit frame. In this way the center pins are located in such a position that the locomotive will exert the least possible lateral pressure on the track, due to curving. These forces were analyzed and it was found that both from the standpoint of lateral pressure on the track and tendency to keep the locomotive progressing in a straight line without nosing, the most desirable location for the center pins was between the Nos. 1 and 2 driving axles of each main truck.

The main wiring diagrams are shown schematically. The twelve armatures are arranged in groups of three connected permanently in series. This arrangement has the advantage of providing a comparatively low voltage across each individual armature while at the same time the size of the cable in the main motor-circuits and motor-switches need be only sufficient to carry the current of a single motor.



Direct-Current

Step	LS	R1	R2	RR2	R3	RR3	R4	RR4	R5	RR5	M1-M2	M3-M4	M5-M6	M7-M8
1	○										○	○	○	○
2	○	○									○	○	○	○
3	○	○	○								○	○	○	○
4	○	○	○	○							○	○	○	○
5	○	○	○	○	○						○	○	○	○
6	○	○	○	○	○	○					○	○	○	○
7	○	○	○	○	○	○	○				○	○	○	○
8	○	○	○	○	○	○	○	○			○	○	○	○
9	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Alternating-Current

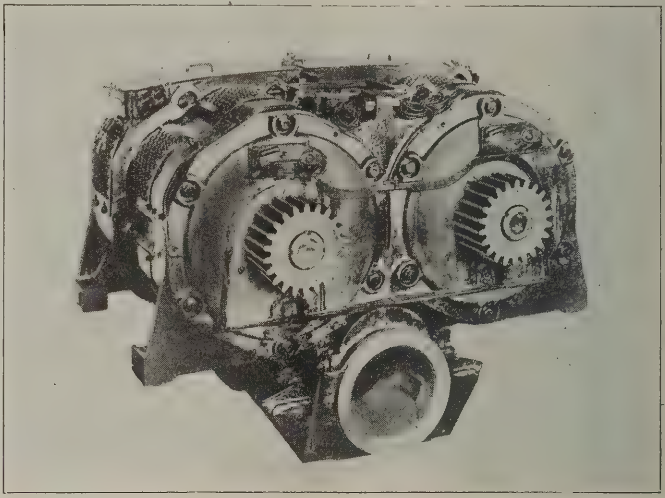
Step	CB	1	2	3	4	5	6	7	8	9	10	11	12	M1-M2	M3-M4	M5-M6	M7-M8
1	○	○												○	○	○	○
2	○	○	○											○	○	○	○
3	○	○	○	○										○	○	○	○
4	○	○	○	○	○									○	○	○	○
5	○		○	○	○	○								○	○	○	○
6	○			○	○	○	○							○	○	○	○
7	○				○	○	○	○						○	○	○	○
8	○					○	○	○	○					○	○	○	○
9	○						○	○	○	○				○	○	○	○
10	○							○	○	○	○			○	○	○	○
11	○								○	○	○	○		○	○	○	○
12	○									○	○	○	○	○	○	○	○

Wiring Diagram and Sequence of Switch Operation

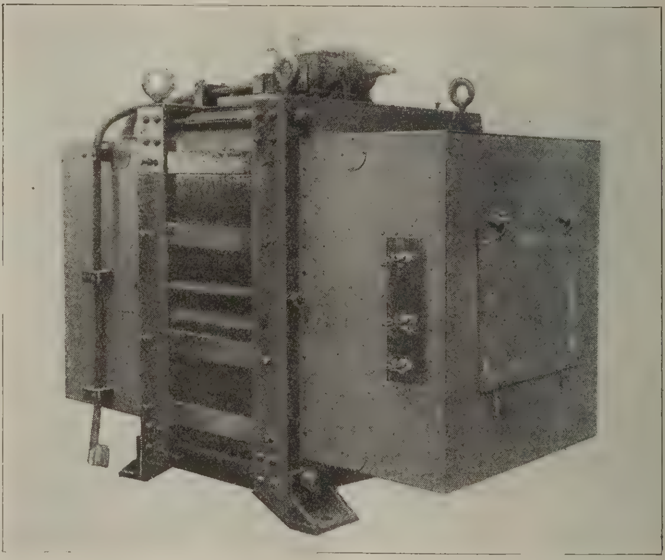
Although these locomotives have a large increase in capacity over the former engines on this road, it was realized that, with the continually increasing hauling capacity requirements, the heaviest trains would ultimately have to be double-headed. The control of the new locomotves has been developed so that multiple operation may be obtained with the gearless locomotives by changing the master controllers of the latter. In this way with either locomotive as the leading unit, the load will be divided in proportion to the rated capacity of the two units.

The main transformer is of the two-circuit air-blast type with a closed metallic circuit on the secondary. The midpoint of the secondary side of the transformer is grounded through a 0.6 kva. transformer with a lamp across this transformer secondary circuit. In case a ground occurs on the secondary side of the transformer, the effect will be merely to establish a circuit through the ground-detector light, which can be reported and the ground cleared before burning occurs. With the closed metallic circuit, as shown, destructive burning can only happen if two grounds occur at the same time, at relatively different voltage points in the circuit.

Another feature is the design of the third rail shoe and operating mechanism. These locomotives, as previously stated, operate on the tracks of the New York Central, which have an underrunning third rail, and the tracks of the Pennsylvania Railroad which have an overrunning third rail. Furthermore, these two third rails are located in a slightly different position, both in respect to height and distance from the center line of track.


Main Twin Motor Showing Quill Bearing

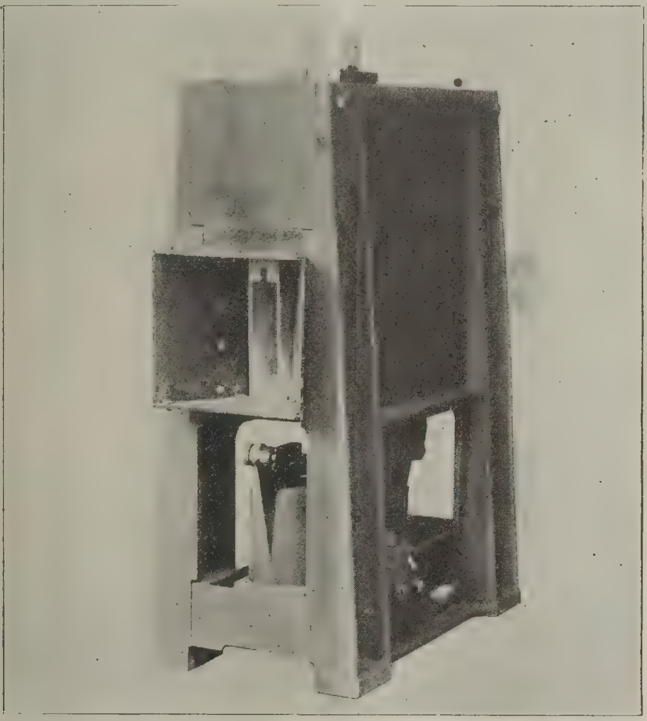
The control and auxiliary circuits are changed-over by an electro-pneumatically operated changeover switch, controlled by two small knife switches mounted on the master controller and used to lower the third rail shoes and to unlock the alternating current pantograph.


Main Air Blast Transformer with Ground Detecting Transformer and Overload Transformer Mounted on Top

The oil circuit breaker can be closed either pneumatically or by hand. It is mechanically latched and electrically tripped. The tripping mechanism is controlled by a time-element relay, so timed as to allow the line section breaker to open ahead of the locomotive breaker in case of short circuit.

The direct-current circuit-breaker is a large, single, electro-pneumatically operated unit switch having a strong magnetic blow-out coil and an automatic trip which operates at a predetermined overload.

Forced ventilation is provided on the locomotives and the ventilation system has been designed to provide an adequate amount of air for the equipment at all times. The air for the blowers is taken from the inside of the cab which acts as a large settling chamber for depositing any snow or moisture which may be drawn from the outside. The blowers are used and are arranged with dampers so that, in the event of failure of one blower, the other blower can supply air to all the equipment for operation of the locomotive at reduced capacity. The blowers are of the forward curved-blade type, which were chosen on account of their small size and low speed for their capacity and pressure. The blower-motors have been designed so that when operated at a lower voltage, they are suitable for driving the air compressors, thus reducing the number of different types of equipment on the engine. Since the safe temperature of the resistance grids is considerably higher than that of the remainder of the equipment, and since it is desirable to cool the main transformer during the periods when the locomotive is operating on direct-current, the main transformer is blown at all times, and the air from the outlet of the transformer is used to ventilate the grid resistance. After passing through the apparatus requiring forced ventilation, the air is exhausted outside of the cab at points remote from the air intake.



Main D. C. Circuit Breaker—Air Operated. Rugged Construction on Account of Cast Iron Base

Air brakes are applied to all of the driving wheels with a separate pair of cylinders for each group. The brake rigging is equalized and the shoes are tandem hung. In addition a hand-brake is provided on each truck unit for holding the locomotive when in a standing position.

The passenger coaches are heated from a kerosene-fired steam boiler installed in the locomotive. Sufficient fuel and water are carried for a one-way trip between New York and New Haven. The water is carried in two main tanks mounted under the cab and suspended from the cab structure. The main reservoir air pressure is maintained in these tanks to force the water into the boiler.

Specifications of New Haven Electric Locomotives

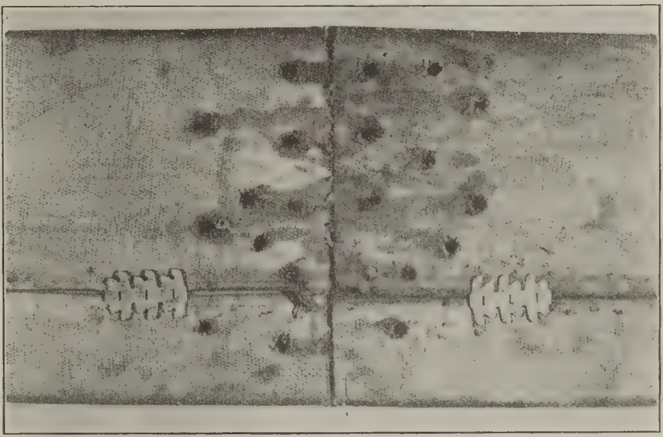
Classification: 2-6-2 + 2-6-2.
Number in service: 5.
Class of service: Passenger.
System and voltage: 11,000 volt A. C.—600 volt D. C.
Number driving wheels: 12.
Diameter driving wheels: 63 in.
Number guiding and trailing wheels: 8.
Diameter guiding and trailing wheels: 36 in.
Total weight, including sand, oil and water, is 170 tons.
Average axle weight is 38,500 lb.
Average pony axle weight is 28,750 lb.
Overall length = 69 ft. 0 in.
Total wheel base = 59 ft. 6 in.
Rigid wheel base = 14 ft. 3 in.
Method of drive = geared.
1 Hr. tractive effort = 21,000 lb.
1 Hr. speed = 36 m. p. h.
1 Hr. hp. of locomotive = 2,000.
Max. speed = 70 m. p. h.

Proper Treatment of Transmission Belts

By E. J. Black, Diamond Rubber Co., Inc., Akron, O.

Transmission belts, like delicate machinery, must be given proper care if the user expects them to give good service. This is such a self-evident truism that it would seem hardly worth repeating and yet it is overlooked repeatedly. Belts which should be good for years of continued service are subjected to abuses which soon render them useless, and in many cases the manufacturer is blamed for having put out a defective product when in reality the belt was faultless.

Unjustified claims for adjustments on injured belts are made frequently by disgruntled users. Every manufacturer can cite dozens of cases.



A Belt Which was Returned to the Manufacturer by the User. It was Torn Along the Length for Several Yards at Either End. An Examination Showed That the Only Cause for the Injury was Improper Lacing.

Recently the Diamond Rubber Company was asked to make an adjustment on a belt which had been torn along the length of the belt for several yards at either end. The user was vehement in his claims that the belt was defective but when an examination of the belt was made it was clearly shown that the only cause for the injury was improper lacing. The holes for the lacing had been punched haphazardly and with no regard for providing an even strain on the belt. The result was that when it was put in use it ripped apart, and the belt was practically ruined.

Improper lacing is probably the most common mistake which users make and yet it is the one which causes the most serious trouble, often completely nullifying all the knowledge and skill which the manufacturer used in making it. There is no excuse for ruining a good belt in this way. By observing the following simple rules the belt will give the best service of which it is capable:

(1) Cut the ends of the belt absolutely square. Do not depend upon your eye or use an ordinary ruler. If the end is slanted in the least degree the pull will come all upon one side of the belt and the consequences are likely to be disastrous.

(2) Make the holes as small as practicable. Use an awl rather than a punch, whenever possible.

(3) Leave a sufficient margin at the edge of the belt without holes so as not to impair its strength. In belts 2 in. wide to 6 in., the holes should not be nearer to the edge than ½ in., in belts 6 in. to 12 in. wide not narrower than ⅝ in., and belts 12 in. to 18 in. wide not narrower than ¾ in.

(4) Make two rows of holes, in parallel lines straight across the width of the belt, and stagger the holes, so that the strain comes upon different portions of the belt.

(5) Be sure that the holes in the two ends to be joined match exactly. Otherwise there will be a "jog" in the belt, and this is likely to result in tearing the belt lengthwise.

(6) Use flexible lacing, being careful to have it proportionate to the size of the belt. A heavy lacing is likely to cause trouble.

(7) In lacing the belt, make the pulley side as smooth as possible. Rough places and ends should be turned away from the pulley.

(8) In using metal fasteners select those which place the strain on the lengthwise strands of the belt. The crosswise strands are not as strong as those which run lengthwise.

Besides improper lacing, there are many other abuses which cut down the life of belts. Shafting that is out of line may cause an undue strain upon the belt and make it run off the pulley. Oil may be allowed to drip upon the belt and ruin it. The belt may be applied with an initial tension so great as to produce an unnecessary strain.

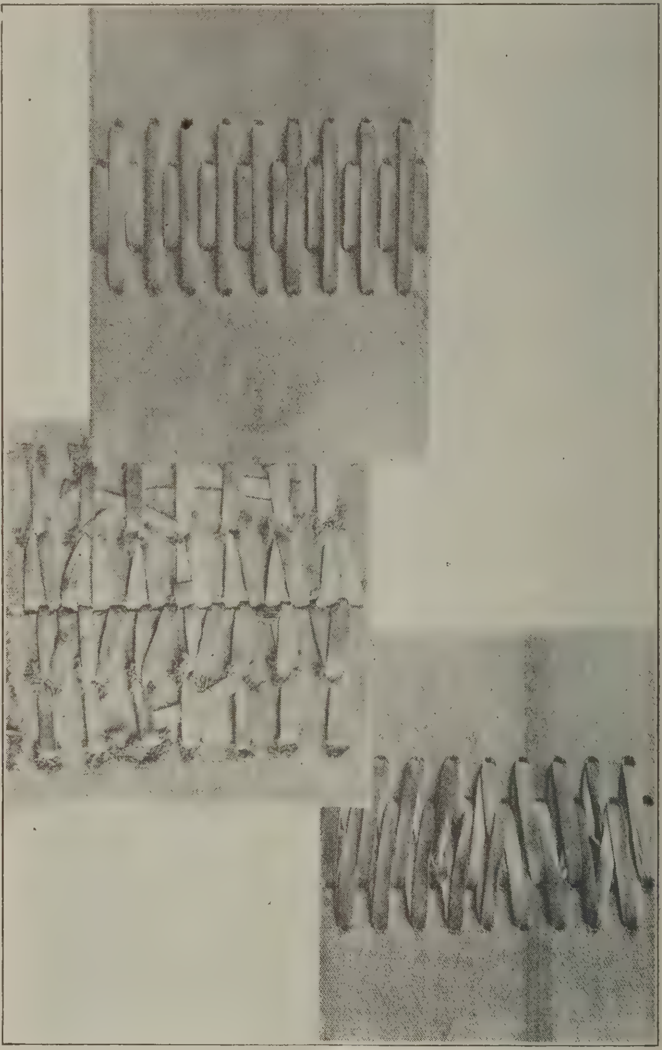
Many complaints regarding unsatisfactory belt performance can be traced to the fact that the wrong belt was used on the job. No matter how good a belt is or how good treatment it receives it will fail to give satisfactory service if not adapted for the use to which it is put.

In deciding upon the right belt for any particular installation there are eight factors to be considered: (1) distance between pulley centers; (2) diameter of the pulleys; (3) width of the pulleys; (4) use of idlers, cone pulleys, quarter turn, half turn, etc.; (5) speed; (6) horse power to be transmitted; (7) load jerky or constant, and (8) conditions such as contact with moisture, oil or other deterioriating influences.

Over these factors the belt man usually has little or no control. His problem is to take the conditions as he finds them, and apply a belt that will give the best service possible under the circumstances. Yet he may sometimes perform a real service by calling attention to a faulty arrangement, when the conditions are such that the fault may be corrected. Real economies may sometimes be effected by lengthening the distance between pulley centers, increasing the width of the pulley face, or by changing the arrangement of a vertical belt so as to give a certain degree of slant.

The factors which are under the belt man's control are these:

(1) The kind of belting to be used,—such as rubber, leather, canvas, etc.; (2) The grade,—whether cheap, medium or high grade, and (3) the weight of the belt, such as 4 or 6-ply, single or double.



The Right and Wrong Way of Lacing Belts are Shown in this Photograph. The Top and Bottom Views Show a Belt Which Has Been Properly Laced. This Middle View Shows a Belt Improperly Laced.

In determining the kind of belting to be used, the merits of rubber belting should receive full consideration. It is economical in first cost, extremely efficient in service, and frequently outlasts other constructions. On the other hand, in places where constant contact with oil is unavoidable, a rubber belt will not give good service. The constant use of shifters is also injurious to a rubber belt.

In deciding upon the right grade for a particular installation, it should be remembered that small pulleys operated at high speed necessitate a high quality belt.

New Electric Motor Cars for the Long Island

Similarity of Old and New Equipment Shows Original Apparatus Has Become Practically Standardized

By S. B. Schenck

THE Long Island Railroad recently ordered from the American Car & Foundry Co., 20 electric motor cars and 50 trailer cars for use in suburban service on its electrified zone which extends over much of the western part of Long Island.

The electrification has been in operation since 1905 and at present comprises over 88 miles of route with 208 miles of electrified track. This installation represents the first large scale electrification of a steam railroad, and it is the most extensive example of multiple unit passenger service in operation.

The fast, frequent and reliable train service given by electric operation has played an important part in the remarkable growth of Long Island's population and consequent freight traffic. Since beginning electric operation the passenger traffic has increased approximately 385 per cent, freight traffic about 193 per cent, and earnings 197 per cent. Statistics for the year 1918 show that the Long Island stands first among all railroads for density of passenger traffic. At present, there are over 532 scheduled electric trains operating daily over this road giving an annual service of over 600,000,000 passenger miles.

This passenger traffic is transported mainly by multiple unit trains operating out of the Pennsylvania station, New York, through the East River tunnel and from the Flatbush Avenue terminal, Brooklyn, to the adjacent suburban territory and seashore resorts. A small part of the traffic is carried by express trains hauled to and from the Pennsylvania Station by electric locomotives. The traffic to the seashore has increased greatly during the past four or five years and the new equipment ordered recently will provide added facilities for handling this traffic.

The multiple unit trains render possible the operation of schedules with close headway because of the ability of such trains to reach a maximum speed in a very short time. The use of motor and trailer cars provides a very flexible system for caring for the varying volume of passenger traffic incidental to all terminals and suburban service, by utilizing trains of the particular capacity required for handling the situation at hand and with motive power correctly proportioned to the size of train. The illustration at the beginning of this article shows an eleven car multiple unit train.

The electric operation over elevated structures, in subways, on the surface, and also the desirability of a system of electric distribution which was standard on connecting lines led to the adoption of the third rail contact line and direct current at 600 volts. The direct current is obtained from rotary converter substations which, in turn, receive alternating current from the Long Island City power house through an 11,000-volt, 3-phase transmission line.

When the 20 motor cars and 50 trailers are placed in service the Long Island Railroad will then have in operation a total of 488 motor cars and 140 trailers all equipped with electrical apparatus manufactured by the Westinghouse Electric & Manufacturing Co. One hundred and thirty-four of the motor cars are equipped with 200-hp. motors, and the other 354 motor cars, including the new cars, are all equipped with 225-hp. motors. The increase in motor capacity is due largely to increased weight of the cars. All motor cars are equipped with Westinghouse automatic type unit switch control.

Trailer cars have been used since the inauguration of electric operation on this road. Some of the trailers are used only during the summer months when the passenger traffic to the seashore is greatly increased in volume. All trailer cars are equipped with control train line, although they are not provided with apparatus for train control from the vestibule, this feature being obtainable from either end of the motor cars that are placed at the ends of the train.

Each new motor car will be equipped with two of the motors shown in Fig. 1. Both of the motors will be mounted on the same truck. This type of motor has been operating with marked success on the Long Island motor cars since the first of them was installed in 1910. The service requires a motor of exceptional ruggedness for operation in the tunnels and subways, as well as at the seashore where loose sand, salt water moisture, and moist salty snow in winter combine to greatly increase the possibilities for failures.

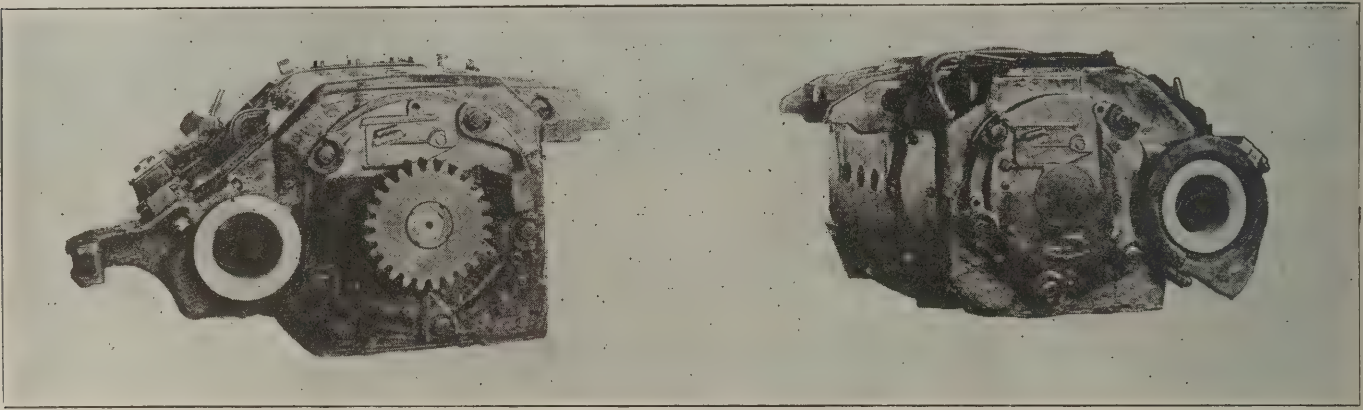
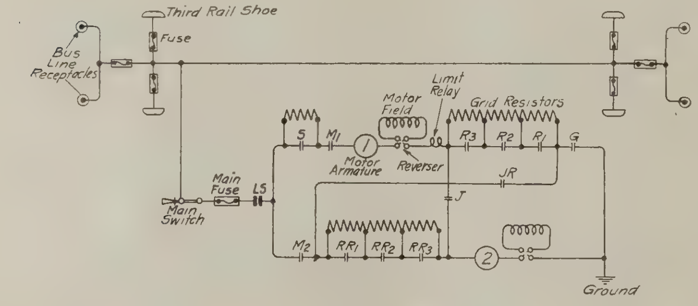


Fig. 1—Westinghouse Type No. 308, 225 Horsepower Motors Used on the Motor Cars

The type No. 308, commutating pole motor embodies the box frame construction which gives a solidly built machine with efficient protection and excellent alinement of all parts. The frame is a one-piece steel casting with large openings bored out at each end for receiving the armature bearing housings and permitting ready removal of the armature for overhauling. Both armature and axle bearings are arranged for oil and waste lubrication. Nose suspension is employed.



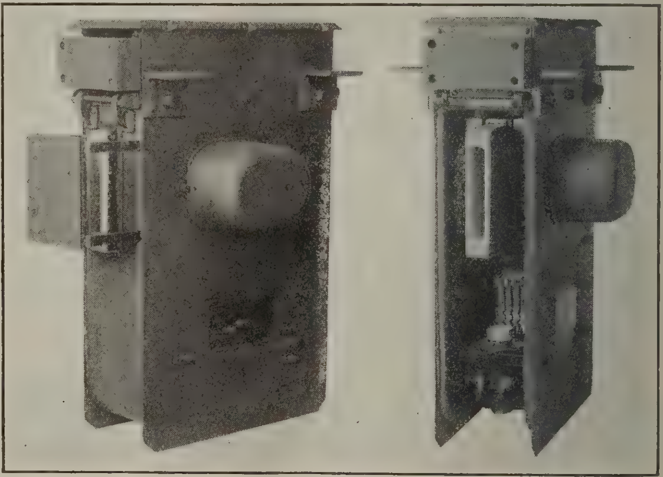
Sequence of Switches

	Step	LS	M1	M2	G	S	JR	J	RR1	R1	RR2	R2	RR3	R3
Series	1	○	○				○							
	2	○	○			○	○							
	3	○	○			○	○		○					
	4	○	○			○	○		○	○				
	5	○	○			○	○		○	○	○			
	6	○	○			○	○		○	○	○	○		
	7	○	○			○	○		○	○	○	○	○	
	8	○	○			○	○		○	○	○	○	○	○
Tran.		○	○			○	○	○	○	○	○	○	○	○
		○	○			○		○						
		○	○	○	○	○		○						
Parallel	9	○	○	○	○	○								
	10	○	○	○	○	○			○	○				
	11	○	○	○	○	○			○	○	○	○		
	12	○	○	○	○	○			○	○	○	○	○	○

Fig. 2—Schematic Diagram of Main Motor Circuits for Automatic Type Unit Switch Control

Type "BP" gears and pinions, with helical teeth, transmit the torque from the motor armature shaft to the axles. The pinion has 25 teeth, two diametral pitch, and is cut from a solid steel forging. It is pressed and keyed on the armature shaft. The gear has 48 teeth, and is machined from a solid steel forging, and pressed on the axle. The gear case is of malleable iron, divided in halves horizontally and supported at the front and rear ends by lugs projecting from the motor frame and motor axle cap.

The automatic type unit switch control equipments ordered for the new motor cars are duplicates of the control equipments furnished for the motor cars in 1905, except for a few minor changes. The original control equipments are still operating and have a remarkable record for reliability, long life of wearing parts, and low maintenance. This record is attained through the use of a control system, using electro-pneumatic unit switches throughout. These switches are operated by compressed air, governed from control circuits that are energized from a low voltage storage battery. Such an arrangement provides action of the switches regardless of the third rail voltage. The heavy pressure obtainable by the use of pneumatic switch insures a good electrical contact of the switch jaws and the low voltage battery control circuits are free from insulation breakdown. The battery provides a means for obtaining emergency braking at any time and also is a source of energy for signal or emergency


Figs. 3 and 4—Types 267-E-9 Line Switch Used With Automatic Type Unit Switch Control

lights when power is not available from the third rail.

The automatic type control embodies the use of a small master controller which directs, through the train line, the operation of the electro-pneumatic unit switches and reverser which effect the necessary connections between the third rail, resistor and motors. The operation of the unit switches is made automatic by means of a limit relay which operates at a predetermined current value to close the switches in correct sequence and accelerate the car at a constant rate. The use of a limit relay to obtain constant accelerating rates prevents abuse of the motors in starting.

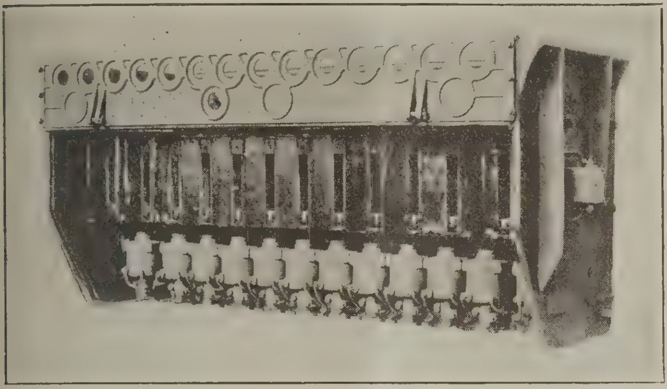


Fig. 5—Type 251-I Switch Group Used With Automatic Type Unit Switch Control

The arrangement of the electrical power circuits and the location of the apparatus in these circuits are shown schematically by Fig. 2.

The sequence of switches in Fig. 2 indicates which switches are closed for each notch during the accelerating of the car. The change from the series to the parallel connection of the motors is made by a bridging transition which maintains torque on both motors during the change of connections. This gives smooth acceleration from the start to the full running speed.

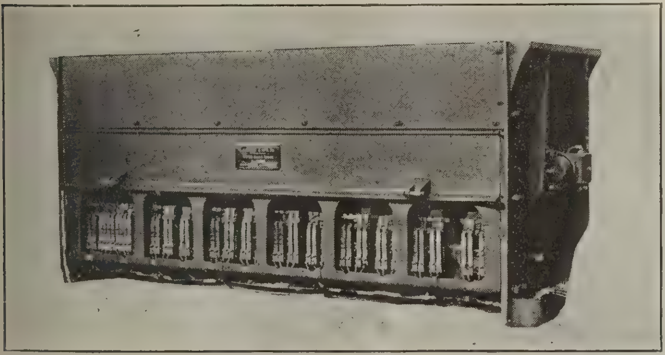


Fig. 6—Opposite Side of Switch Group Shown in Fig. 5

The master controller, limit relay, and control train line details are of standard Westinghouse construction for such service and present no unusual features. The main power circuit control apparatus, however, has some interesting features.

One of the features of the control on both the old and the new cars is the use of a circuit breaker or "line switch" mounted separately from the main group of unit switches. This line switch is operated electro-pneumatically in the same manner as the unit switches. It acts as a circuit breaker to disconnect the motors from the line in case of overloads or grounds on the motors. Any heavy abnormal arcs are thus removed entirely from the switch group and confined to one piece of apparatus built for heavy arcing duty. The general appearance of the line switch with the side covers closed and open is shown by Figs. 3 and 4 respectively.

The twelve individual electro-pneumatic switches are assembled with blowout coils in one group similar to that shown on Figs. 5 and 6.

These switches, like the line switch, are closed by compressed air working against a heavy spring that normally holds the switch open. The heavy spring insures a positive opening of the switch. The compressed air is admitted to the switch cylinder by means of a small air valve which is operated by an electro-magnet. This magnet is energized from the control train line circuit which extends through the entire train from the master controller at the head end of the train.

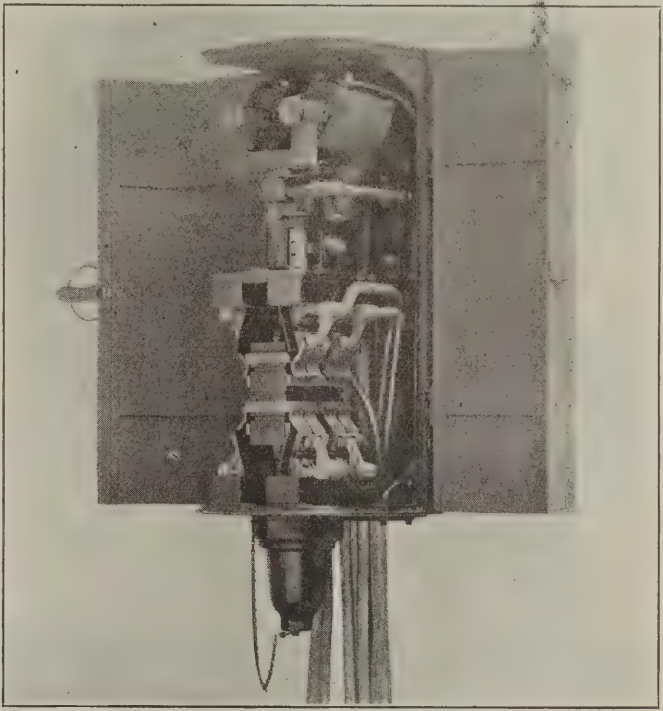


Fig. 7—Type 176-H Reverser Used With Automatic Type Unit Switch Control

The direction of motion of each car is governed by the reverser shown in Fig. 7. One reverser is mounted on each car. The reverser changes the direction of rotating of the motors by interchanging the connections to the motor fields. This interchange is made by contacts carried on a two position movable plunger that is moved to one or the other position by compressed air admitted to pistons through the air valves. These valves are similar in operation to those in the switch group.

One section of the grid resistors required for varying the voltage across the motors during acceleration is shown by Fig. 8. The individual cast-iron resistor grids are made for three-point support and assembled between sheet steel end plates. Each assembly makes one complete unit.

It is interesting to note the arrangement of the bus and train line connections for the new cars. At both ends of the car the bus and the train lines are run to their respective receptacles and also to respective jumper heads. The receptacle is fastened direct to the car. The jumper head is attached to a length of flexible cable that is permanently connected to the circuit on the cars. When cars are coupled together the jumper head on one car is inserted in the receptacle on the other car, thus extending the circuits from car to car. When not in use in this manner, the jumper head is held in a "dummy" receptacle fastened to the end of the car. This arrangement effectually prevents loss of the jumpers.

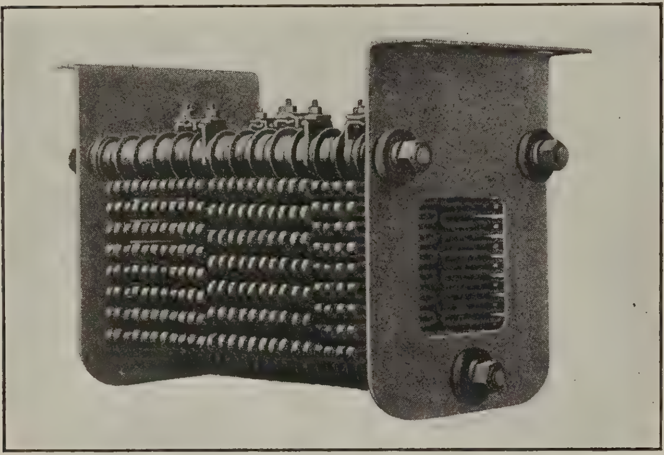


Fig. 8—Grid Resistor Used With Westinghouse Automatic Type Unit Switch Control

The control train line is energized from 14 volt storage battery. Two batteries per car are employed, one battery being used to operate the control while the other battery is being charged. When charging, the battery is shunted by resistance that is connected in series with the motor of the air compressor. A relay disconnects the battery from both the shunt and compressor motor circuits when the compressor motor is not running.

All the control apparatus except the master controller, limit relay, and small control cutout switches is located beneath the car body. The wiring connections between the various pieces of apparatus are carried on iron conduits, making a very substantial and reliable construction. The apparatus is so located on the car that quick and thorough inspection is facilitated.

It is worthy to note that, for the new cars, the control equipment is practically a duplicate of that installed 15 years ago. The motors are duplicates of those in service for the past 10 years, showing that the electrical equipment on the Long Island Railroad has become standardized on a type that has proved successful in the heaviest kind of multiple unit passenger service.

Storage Battery Men Convene

Members of the motive power battery sales department of the Electric Storage Battery Co. gathered recently in Philadelphia for their first annual convention. Sixty men were present from points as far west as Denver, as far south as Atlanta and on the north from Canada. The sessions were given over to a close study and review of the storage battery possibilities in connection with the propulsion of electric street trucks, electric industrial trucks and electric mine locomotives.

The convention was held in the Green room of the Bellevue-Stratford, April 29, 30, May 1, and was called to order by H. B. Gay, acting sales manager of the Electric Storage Battery Co. With the beginning of the first business discussion, W. Van C. Brandt, sales manager of the motive power battery sales department presided as permanent chairman.

The discussion of the first day covered the various accomplishments of the Electric Storage Battery Co. in these fields during 1919 and the planning of ways and means for making 1920 sales as nearly 100 per cent efficient as possible. Following the second day's session, members were conducted through the factory of the Electric Storage Battery Co., 19th and Allegheny Ave. After the trip through the plant, the members of the convention met in banquet at the Manheim Cricket Club following which inter-city bowling contests were held in the club alleys.

Members of the Motive Power Battery Sales Department of the Electric Storage Battery Company at their First Annual Convention, Recently held at Philadelphia

Types of Direct Current Magnetic Controllers

A Description of Some of the Equipment Used In Remote Control of Direct Current Motors

By Gordon Fox

THE need for starters and controllers which might be located remote from the operator and which might have automatic features, led to the development of many and varied designs. The two types which have survived to greatest prominence are the solenoid starter and the unit contractor type of controller.

The solenoid starter is little more than a face plate starter operated by a solenoid, with a dash pot provided to delay the action and to introduce the desired time element. Fig. 1 illustrates a starter of this type and Fig. 2 gives a typical diagram of connections. This type of device is restricted to starters for comparatively small motors. In this field it finds a moderate use.

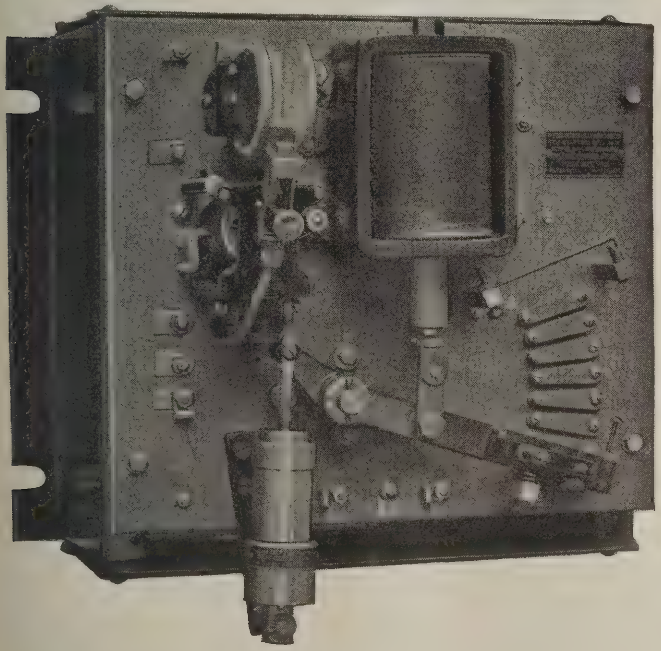
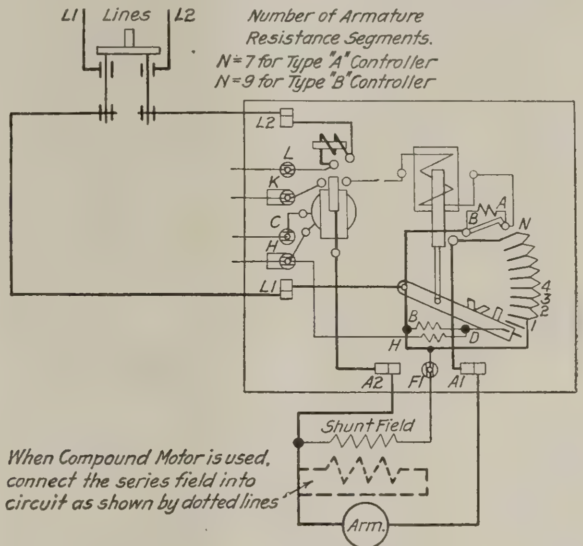


Fig. 1—Solenoid Operated Face Plate Starter for D. C. Motor

Unit type magnetic contactor starters and controllers are now used for the great majority of remote or automatic control applications. This type of control has a flexibility enabling its ready adaptation to a great variety of conditions. The performance can be most readily predetermined and adjusted. The control may be made to function largely independent of the operator, preventing motor abuse. These features coupled with the satisfactory and reliable performance of the modern magnetic contactor, place this type in the front rank of motor control devices.

The unit type magnetic controller comprises an assembly of magnet operated contactors each of which performs a function by opening or closing a circuit or circuits in such a manner as to contribute to the required performance of the controller as a whole. For instance, in a simple starter, one contactor may connect the motor to the line and other contactors may cut out the starting resistance.

The basis of unit type magnetic control is the magnetic contactor. There are many designs of contactors differing in details but similar in essential features. The so-called "clapper" type of contactor has been found by experience to be best suited for handling main circuits while the solenoid and plunger design is used extensively for relays handling control circuits.


L1
Lines
L2
Number of Armature Resistance Segments.
N=7 for Type "A" Controller
N=9 for Type "B" Controller
L2
L
K
C
H
L1
A
B
N
4
3
2
1
B
D
H
A2
F1
A1
Shunt Field
When Compound Motor is used, connect the series field into circuit as shown by dotted lines
Arm.
Fig. 2—Connections for Solenoid Operated Face Plate Starter

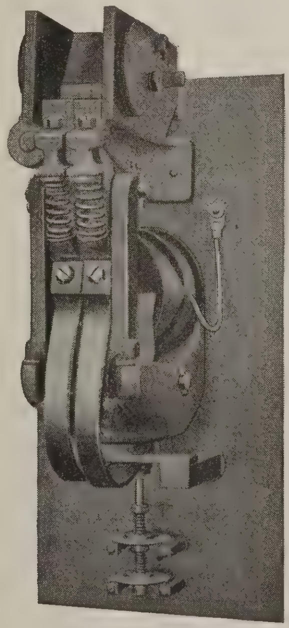


Fig. 3—Clapper Type Magnetic Contactor for Direct Current

A clapper type magnetic contactor is illustrated in

Fig. 3. It comprises essentially an iron yoke carrying a coil, an armature, pivoted at its lower end and contact fingers attached to both stationary and moving elements. The contact fingers are ordinarily of solid copper. The design is such that these fingers make and break the circuit at their extreme tips but maintain the circuit through a line contact at the heel of the contact fingers. Fig. 4 shows the different positions of a pair of contact fingers while closing. The rolling effect is secured by mounting the movable contact on a hinged part, as shown. The spring functions to cause the tips to close first and open last. It also serves to permit the armature to close completely, exerting comparatively heavy pressure between the contacts. It also aids in causing the contactor to open with a quick, snappy action.

Although the contact fingers, when fully closed, have only a line contact, surprisingly heavy currents may be carried without undue heating. This is because a heavy pressure is exerted along the line of contact and also because the heat generated at the contact line travels quickly into the body of the contact fingers which are heavy enough to absorb and dissipate this heat. A magnetic blowout feature is provided on such contactors as are called upon to open circuits carrying heavy currents. There are many fine points in the design of contactors which have been developed through experience and which contribute to the successful performance of these units.

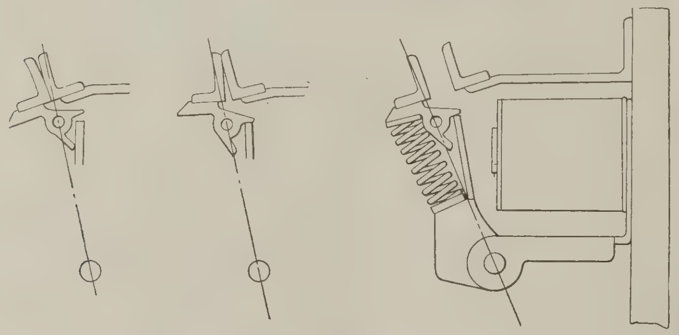


Fig. 4—Positions of Magnetic Contactor Fingers in Closing, Showing Combined Rolling and Sliding Action

Most contactors function to close a circuit. When the coil is energized the separated contact fingers are brought together. When the coil is de-energized the contacts are separated and the circuit is opened. The contactor opens by gravity assisted by the contact finger spring. Some contactors function to open a circuit which is normally closed when the coil is de-energized. The spring closed contactor shown in Fig. 5 is an example of this type. A contactor may be both circuit opening and circuit closing. Fig. 6 shows a contactor of this type. The upper coil causes the upper contacts to close. When the coil is de-energized the contactor falls open by gravity, closing the lower contacts. The lower coil then acts to seal these contacts together under pressure and prevent a rebound. The majority of contactors are single pole. Double pole and multi-pole contactors find considerable use. Fig. 7 illustrates a two pole contactor.

The coil for a magnetic contactor is more commonly provided with a large number of turns of small wire and is adapted to be connected across line voltage. A contactor of this type is called a "shunt" contactor. There are many variations. Some contractor coils are designed for less than line voltage and are connected in series with resistance. In some cases the coil is connected across full voltage while closing and resistance is then cut in series with the coil by an auxiliary contact on the contactor. This is to give a brisk closing action and to reduce heating of the coil while merely retaining the armature in the closed position. Sometimes the coils of two or three contactors are connected in series across the line. Sometimes the coils are connected across the motor armature, responding to armature counter volts. In other cases the coils are connected across the resistance, their action depending upon the resistance drop. These methods are all employed by different manufacturers and for different purposes.

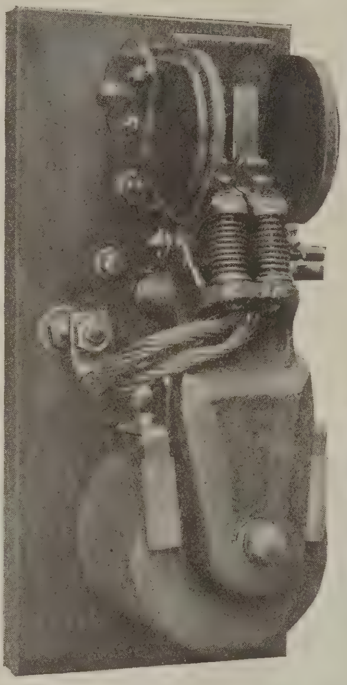


Fig. 5

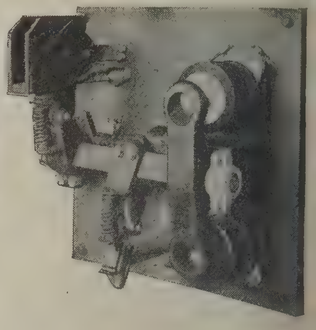


Fig. 6

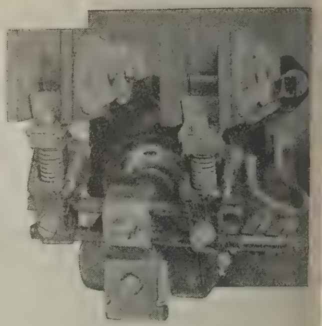


Fig. 7

Fig. 5—Spring Closed, Magnetically Opened Contactor for Direct Current

Fig. 6—Direct Current Contactor with Gravity Closed "Back" Contact

Fig. 7—Two Pole Direct Current Contactor Unit

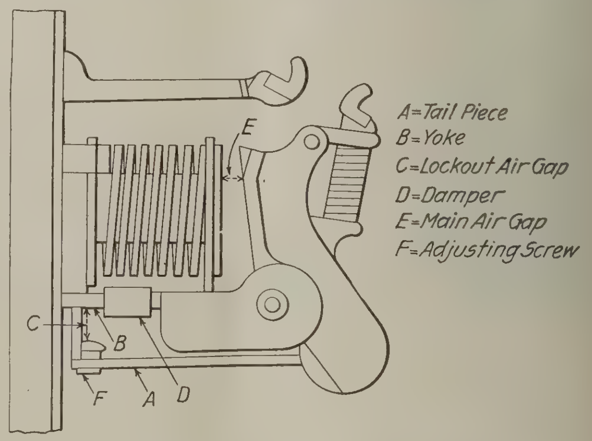


Fig. 8—Diagram of Series Lockout Contactor

Shunt contactors are commonly designed to close at a voltage somewhat less than their rated voltage so as not to be unduly affected by low voltage conditions. These contactors, once closed, may be retained in the closed position on a relatively low voltage.

It will be appreciated that shunt contactors are operated by comparatively light currents which can be handled successfully by push buttons, master switches, relays, interlocks and similar devices in their control circuits.

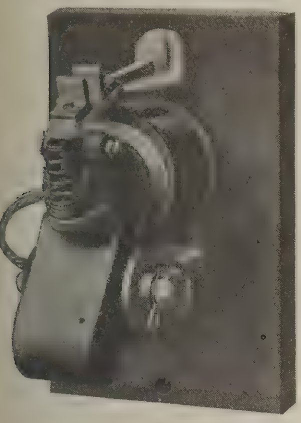


Fig. 8a

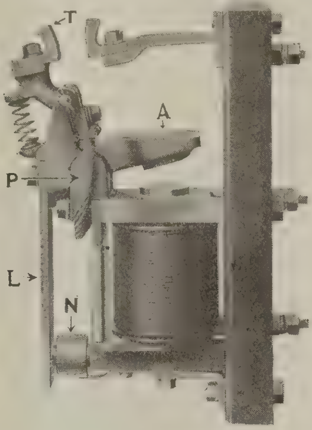


Fig. 9

Fig. 8a—Lockout Contactor Shown Diagrammatically in Fig. 8.
Fig. 9 —Another Type of Series Lockout Contactor; Armature (A), Moving Contact (T), Pivot (P), Tail Piece (L), Lockout Adjustment Nut (N)

The coil for a magnetic contactor may be made up of a few turns of heavy wire and adapted to be connected in series in the main motor circuit. The use of this construction is largely restricted to the so-called "series lockout" contactor. This contactor is designed for use with its coil in series with a circuit carrying a fluctuating current. The contactor is designed to "lockout" or hold open on high values of current but to close when the current falls to a prescribed value. This selective action is secured automatically through characteristics inherent in the contactor and not by means of auxiliary apparatus. This peculiar action is secured by providing the contactor with two magnetic circuits. The flux in one circuit tends to close the contactor. The flux in the other circuit has a net tendency to hold the contactor open. For high values of current a considerable flux flows through the second or holding out circuit due to the fact that the parallel portion of the first circuit is magnetically saturated. For lower values of current there is comparatively little flux through the holding out circuit because the main circuit is not saturated and the air gap in the holding out circuit introduces relatively high reluctance in that circuit. By adjusting this air gap it is possible to vary the current value at which the contactor will close. Figs. 8 and 9 illustrate the principal features of two different types of series lockout contactors both of which operate upon similar principles.

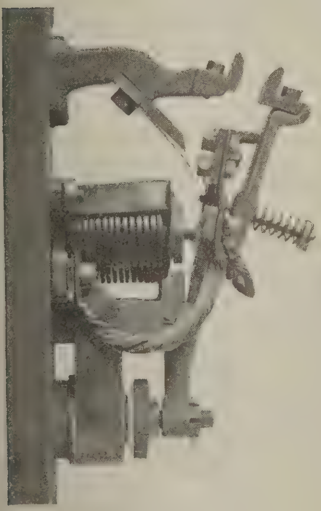


Fig. 10

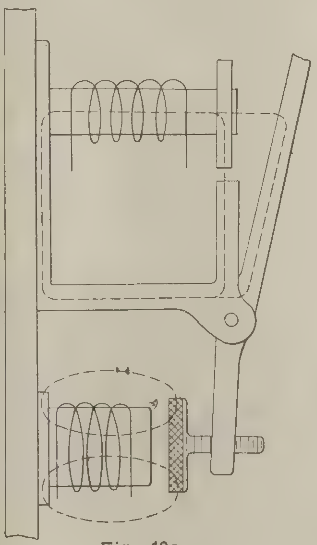


Fig. 10a

Fig. 10—Series Lockout Contactor, Two Coil, Opposed Magnet Type
Fig. 10a—Schematic Diagram of Contactor Shown in Fig. 10

It should be noted if the current through the coil of a series type contactor falls below the holding in value, the contactor will drop open. Series contactors are made to hold in on relatively small currents, however. Sometimes a comparatively light shunt coil is provided to act as a "holding in" coil after the series coil has closed the contactor. It may be noted that contactors with series coils may be de-energized either by opening the series circuit or by short circuiting the operating coil.

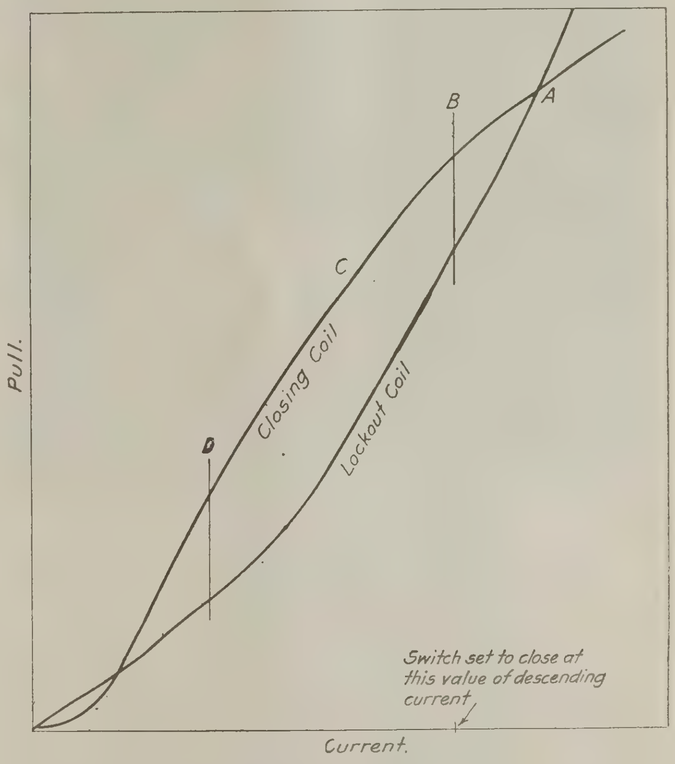


Fig. 10(b)—Magnetic Conditions in Series Lockout Contactor, Two Coil Opposed Magnet Type

Another type of "series lockout" contactor operates on a quite different principle. Fig. 10 illustrates a contactor of this type. Both the upper coil, tending to close the contactor, and the lower coil, tending to hold open the contactor, are series wound. The iron in the circuit of the closing coil is worked near saturation. This coil exerts a strong pull at low current values with little increase after saturation is reached. The iron in the circuit of the lockout coil is not saturated, so that the pull of this magnet increases more rapidly with the heavy currents.

For light currents the closing coil predominates and closes the contactor. For heavy currents the effect of the lockout contactor is sufficient to hold the contactor open. By changing an air gap in the magnetic circuit of the lockout coil the closing current value can be adjusted.

Contactors are frequently provided with auxiliary contacts of comparatively light construction. These auxiliary contacts serve to open or close control circuits to interlock or inter-relate the functions of the individual contactor units.

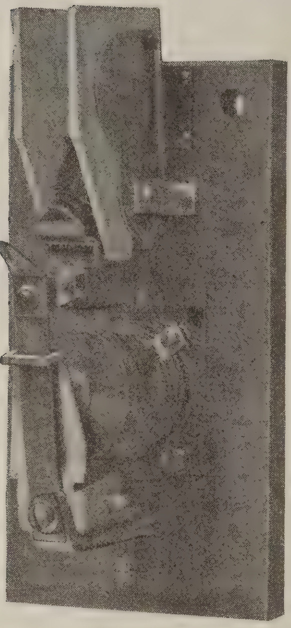


Fig. 11

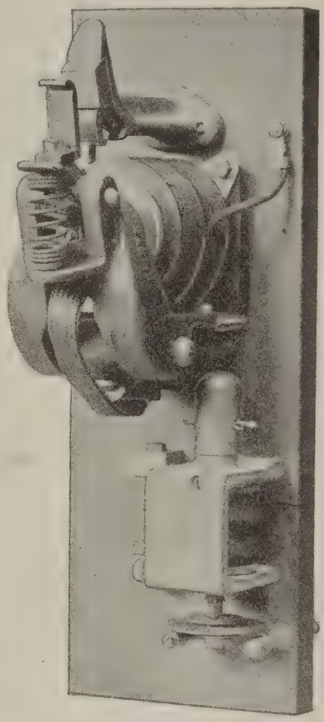


Fig. 12

Fig. 11—Clapper Type Relay—Direct Current

Fig. 12—Accelerating Contactor with Current Limit Accelerating Relay in Conjunction

Relays play an important part in the action of many magnetic controllers. The functions which they perform are varied. The designs are equally varied. They may be of either the clapper type or the solenoid and plunger type. They may carry shunt coils, series coils or both. A simple clapper type relay is shown in Fig. 1. This may be provided with a shunt winding, arranged to be connected across line voltage and used to provide a no-voltage protection feature. Upon failure of voltage the relay opens. It is so connected in the control circuit that it is then necessary to operate the push button or master to reset the relay and actuate the controller proper. Or the relay coil may be connected in series with the shunt field of a motor and the contacts arranged to open the main control circuit if the shunt field circuit opens. There are many uses for relays of this general type.

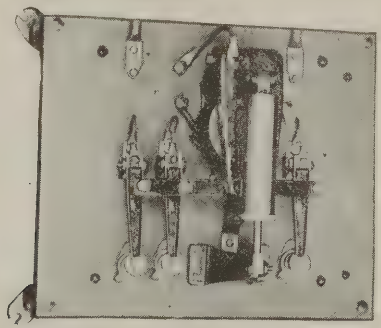


Fig. 13—Combined Current Time Element Accelerator

Accelerating relays are much used. Fig. 13 shows an accelerating relay operating on a time element principle. When the relay coil (ordinarily shunt wound) is energized, the armature closes instantly. This compresses a spring transmitting torque to the contact bearing member, causing it to close slowly, retarded by the dash pot. This type of relay is used to control the cutting out of resistance in motor acceleration.

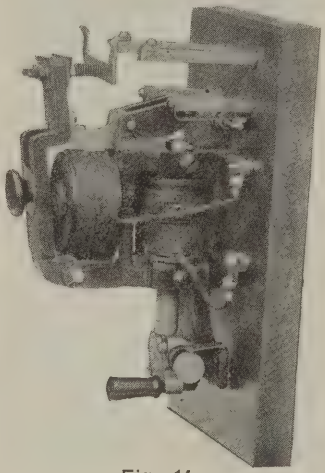


Fig. 14

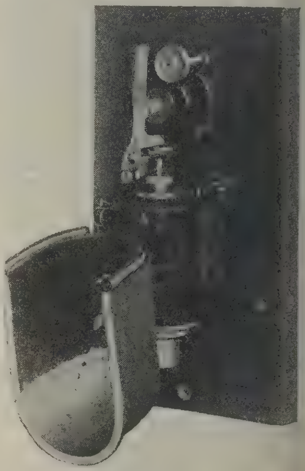


Fig. 15

Fig. 14—Instantaneous Trip, Magnetic Reset Overload Relay

Fig. 15—Overload Relay, Time Element Trip Instantaneous Reset

Many accelerating relays operate on the current limit principle. They carry series coils and operate to hold open their contacts under heavy currents but to allow them to close when the current falls to a prescribed value. Fig. 12 shows an accelerating relay of this type. Relays of this type are often mechanically interlocked with contactors so that they are held open mechanically

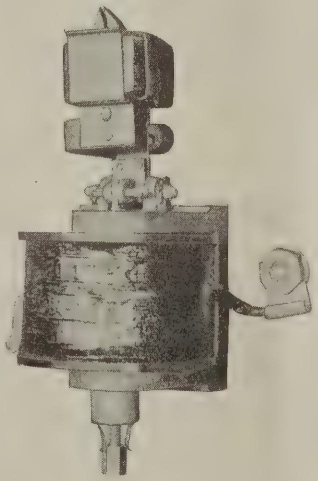


Fig. 16

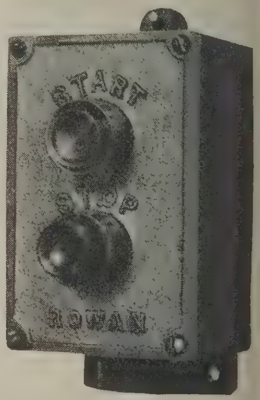


Fig. 17

Fig. 16—Fluttering Relay

Fig. 17—Two Point Push Button Master Switch

until the contactor closes, allowing the relay to function to govern the further action of the controller.

Overload relays are provided on the majority of control panels. These relays take many forms. Figs. 14 and 15 show two types. Series coils only or series and shunt coils are provided. Where series coils only are provided the relay will hold open only while the current remains heavy, unless a retaining catch is supplied. Where both series and shunt coils are supplied the series coil acts to open the relay and the shunt coil then suffices to hold it open so long as the current remains on the shunt coil.

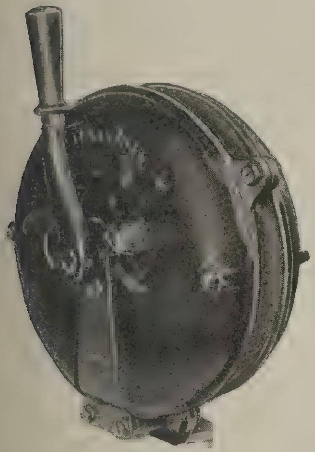


Fig. 18

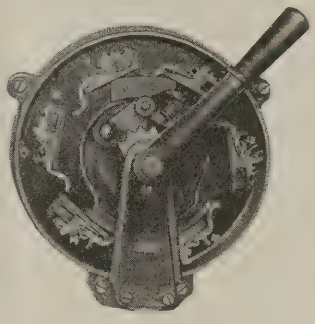


Fig. 19

Fig. 18—Pancake Type Master Switch

Fig. 19—Internal Arrangement of Pancake Type Two Point Master Switch

Overload relays may be either instantaneous in their action or a time element may be introduced through the use of a dash pot. The relay shown in Fig. 14 is an instantaneous trip relay while that shown in Fig 15 has a time element feature. Such relays ordinarily have an inverse time action requiring little time to open under a short circuit but acting rather slowly under a moderate overload. Overload relays may be further described as *instantaneous reset, automatic reset, hand reset.* The instantaneous reset relay closes at once when the current falls in its operating coil. The automatic reset relay, once opened remains open until reset, either by opening its shunt coil circuit, if of that type, or by energizing a reset magnet. Hand reset relays, once open, remain open until reset by hand. Each type finds applications according to the conditions to be met.

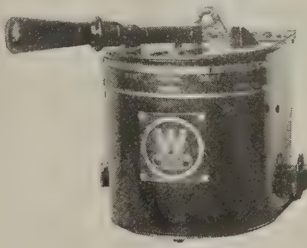


Fig. 20—Combined Drum Reversing Switch and Master Controller for Direct Current Motor

Some relays series wound, are so designed as to close at a definite current value, to hold closed at all greater currents and to fall open when the current falls below this value. A relay of this type is called a fluttering relay. One design is shown in Fig. 16. Relays of this type are often found on starters for adjustable speed motors. The relay coil is connected in the armature circuit. The relay contacts short circuit the field rheostat while the motor accelerates or at any time that an overload occurs.

A few of the more common relays have been described above. There are many variations and many special designs, some being quite complex. These cannot be covered in a general discussion.

The majority of motors are expected to function subject to the will of an operator. Some motors are arranged to perform automatically, governed by some feature in connection with the process or operation performed. The device which enables the operator to govern the action of a magnetic controller is designated as a master switch. The simplest form of master switch is the push button. A unit or station comprising one or more push buttons enables the operator to start, stop, inch or otherwise govern his starter or controller. Fig. 17 illustrates a common form of two button push providing start and stop features only. This unit makes momentary contact in starting when the start button is depressed and a momentary break is made while the stop button is depressed. In other types the push button circuits are not momentary. A walking beam device is then used to interrelate start and stop or other functions.

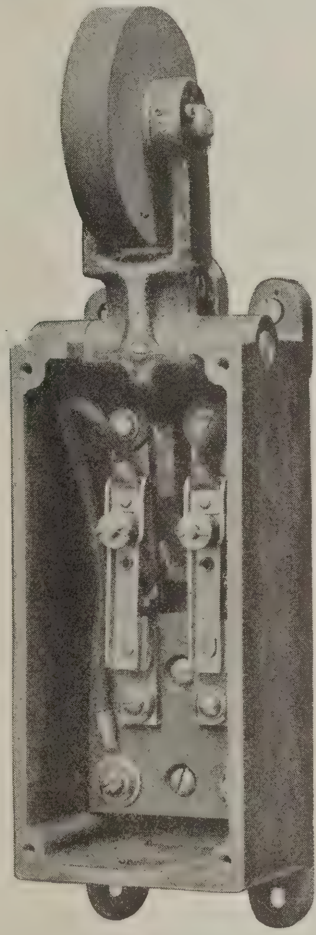


Fig. 21—Hatchway Type Limit Switch

A simple form of master switch is illustrated in Fig. 18 and its internal arrangement shown in Fig. 19. This master is somewhat more complex than the push button type. It provides two directions of throw, usually arranged to give reverse rotation of the motor. Two steps are provided in each direction of throw, more commonly arranged to obtain two speed points. A contact is made at the off position of the master, usually serving as a reset for the no voltage release feature. This so-called "pancake" master is a simple and rugged device and serves excellently where the control required is comparatively simple.

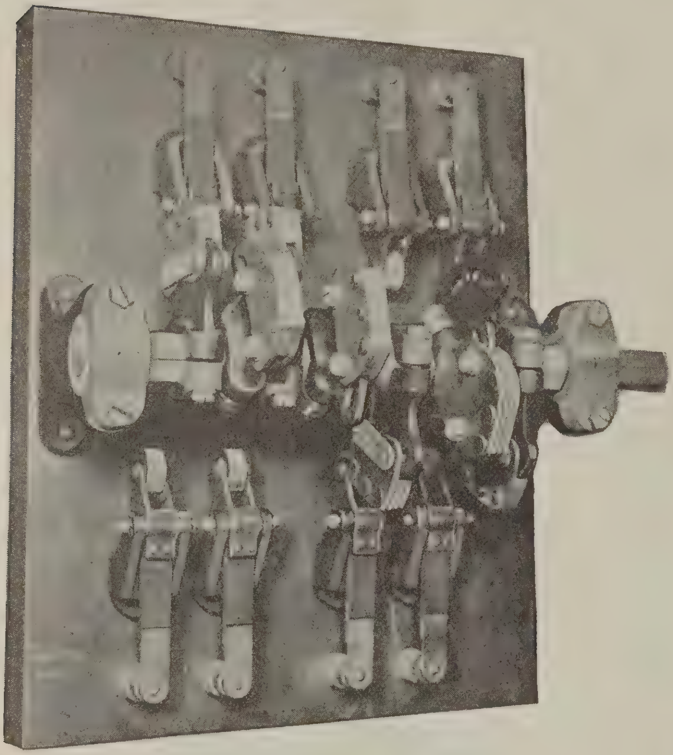


Fig. 22—Cam Type Limit Switch

More elaborate master switches are required when the control by the operator is more complete or complex. These masters more commonly follow the drum design, being, in reality, small drum controllers handling control circuits only.

In some cases direct and indirect control are combined in such a manner that the main motor circuits are handled partly in the manual controller and partly by a magnetic contactor panel. The manual controller carries control circuits also and serves the double function of controller and master. Masters of this type are usually of a modified drum design.

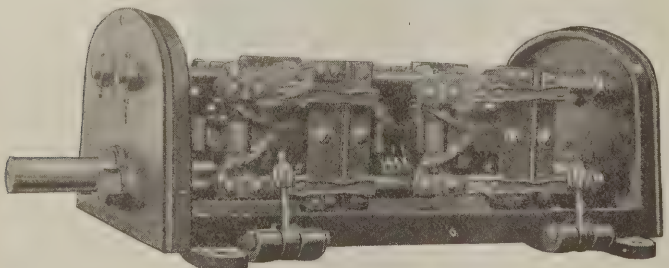


Fig. 23—Screw or Traveling Nut Type of Limit Switch

A limit switch is a device actuated mechanically by some motion of the driven mechanism, to make or break a contact or contacts and thus to bring about a change in the action of the motor. More commonly the limit switch acts to cause the motor to slow down or stop as it approaches the end of a cycle or travel. Most limit switches handle control circuits only, such an arrangement being generally preferable. They are sometimes arranged to handle the full motor current, however. Fig. 20 shows a combined drum reversing switch and master controller for direct current motor.

Limit switches, being contacting devices, take a variety of forms, being similar, in some cases to mechanically actuated controllers or masters. Figs. 21, 22 and 23 illustrate, respectively, hatchway, cam and screw types. Hatchway and track limit switches are actuated by some form of trip device. The other types are usually coupled or geared to the driven machine.

A Tractor on a Grade

Much is expected and required of the electrical industrial tractor, but the performance illustrated in the photograph is somewhat unusual for even one of these motive power units. The picture shows a Q. T. Q. Baker tractor of the four-wheel drive type, equipped with 24 cells of 19-plate Ironclad-Exide battery, pulling two loaded trailers up a 25 per cent grade.

The occasion was at the Cleveland Electrical Show which was held a few weeks ago in the new Winton Garage building. The building was not provided with elevators but has a 25 per cent ramp running from the first to the third floor. The tractor pulled all of the heavy machinery exhibits up this ramp to the third floor, loads running as high as ten tons.

Tractor Pulling a Heavy Load Up a 25 Percent Grade

Few people realize how steep a 25 per cent ramp is. This one was found too steep for practical purposes and the owners of the building are tearing it down to be replaced by a ramp with an easier slope.

In the long run the whole people are more concerned in the steady, regular and efficient operation of the railroads than either the railroad owners or the railroad workers.—*Yonkers (N. Y.) Statesman.*

Pasadena Convention Discusses Heavy Traction

Committee on Electrification of Steam Railroads Presents a Number of Interesting Papers

At the forty-first convention of the National Electric Light Association, held at the Hotel Huntington, Pasadena, Cal., from May 18 to 22, there were very few subjects having a bearing upon the electrical industry, that were not discussed. Among others a lengthy symposium on the subject of heavy electric traction was presented. The Committee on the Electrification of Steam Railroads was composed of the following members: F. M. Kerr, vice-president, Montana Power Company, chairman; A. H. Armstrong, chairman, Electrification Committee of the General Electric Company; R. Beeuwkes, electrical engineer, Chicago, Milwaukee & St. Paul Railway; H. H. Cochrane, chief engineer, Montana Power Company; Peter Junkersfeld, engineering manager, Stone & Webster; F. H. Shepard, director of heavy electric traction, Westinghouse Electric & Manufacturing Co.; J. E. Woodbridge, resident engineer, Ford, Bacon & Davis, San Francisco.

In introducing the subject Mr. Kerr stated that the committee had felt it would be better to present a number of papers bearing upon the different phases of the work. In this way the viewpoint of the producer of electric power could be had as well as that of the consumer. Most of the papers were prepared by members of the committee, and since these men are ardent advocates of electrification it is not surprising that the tone of the papers read was optimistic.

Mr. Kerr explained that personally he felt that the experimental stage of the electrification of steam railroads had been passed and that the application of electricity to this field had been so successfully demonstrated that its further extension upon other roads was merely a matter of securing the necessary capital. In making comparison between the steam locomotive and the electric, Mr. Kerr pointed out some of the disadvantages of the former, such as the limitations of boiler capacity, low-grade fuel, impure water, and extreme cold weather. With the introduction of the electric locomotive, he said, these difficulties are all eliminated and the electric locomotive becomes merely a machine for hauling trains. Mr. Kerr also placed emphasis on the fact that the power used by locomotives should be generated by a power company rather than by the railroad itself, for the reason that power companies having a much wider experience in this field, understand the problems involved better than do the railroads.

In comparing the relative economies of electric and steam operation, Mr. Kerr pointed out the following items:

(1) The cost of coal should be taken at its actual market value delivered at the point of use.

(2) Comparison of maintenance cost should include not only locomotives but also cars, for especially on mountain divisions where regenerative braking is used the rolling stock of the road is subjected to much less abuse with electric than with steam operation.

(3) The cost of obtaining and frequently of treating water for boiler feed is an item of considerable importance chargeable to steam but not to electric operation.

(4) The highest speed at which cars can be hauled over roads with electric operation shows the same amount of freight to be handled with considerably fewer cars.

(5) With the size and speed of trains increased by electric operation the item of train labor is reduced, and roundhouse and shop labor is reduced even more.

(6) The cost of purchasing electric energy is in some cases given undue prominence by roads considering electrification. That this is not necessarily a controlling item is indicated by the following figures: The total yearly cost of operation on the Chicago, Milwaukee & St. Paul Railway averages about $11,000 per mile for the entire system of 10,000 miles. The cost of electric energy purchased for the Rocky Mountain division is $1,600 per mile, or less than 15 per cent of the average total cost for the system.

The Railroad as a Power Consumer

In discussing the power end of the electrification problem, Mr. Cochrane, of the Montana Power Company, based his remarks upon the experience obtained in supplying power to the St. Paul and to the Butte, Anaconda & Pacific. In his remarks Mr. Cochrane pointed out that it would have been much more expensive for the St. Paul to have undertaken to generate its own power than it has been by purchasing this power from the power company. His argument was based upon the fact that the railroad company would have been obliged to build approximately 700 miles of high voltage line as compared with 400 miles of such line which they actually did build. Such additional high-voltage transmission line as was required was constructed by the power company and in their capacity as power producers part of the power transmitted over these lines was used by the railroad and part for other purposes. Furthermore, a suitable power site would have been difficult for the railroad company to find.

The ultimate solution as suggested by Mr. Cochrane for future electrification projects would be for the power company to own all of the high-voltage power lines and for the railroads to own all of the substations. In this way the power company would be so situated as to supply needs other than those of the railroad. Of course, transferring a portion of the investment from the railroad to the power company, would necessitate a higher rate for power, although the final cost to the railroad company is practically the same, since it is not burdened with the additional high-voltage line investment.

Power Rate

In the discussion of the power rate the fact was clearly developed that from the railroad point of view the straight kilowatt hour rate would be ideal, but that from the power company's point of view such a rate would hardly be feasible. A compromise must, therefore, be arrived at and this can be accomplished by placing the greater part of the charge on the small amount of energy taken, but with a small maximum-demand charge which offers a sufficient incentive for the railroad company to keep its power demand as low as practical for good operation.

Electric versus Steam Locomotives

In discussing his portion of the symposium, A. H. Armstrong of the General Electric Company devoted much of his paper to a comparison between the steam and the electric locomotive, pointing out the numerous advantages of the latter. Unlike the steam locomotive, he said, the electric locomotive has an unlimited supply of power, and for this reason can be constructed for any tractive power and for any speed that future transportation requirements may demand. He further stated that the steam engine was consuming 25 per cent of all of the coal mined in the country as well as 6 per cent of the oil, whereas the electric locomotive can utilize water power wherever it is available, or if dependent upon power derived from coal fired stations it could haul the tonnage of the country with a much lower expenditure for coal than is possible with the steam locomotive.

Mr. Armstrong emphasized one of the greatest advantages of the electric locomotive in mountain railroading—regenerative braking. Due to this unique and exclusive feature of the electric locomotive, new levels for low maintenance cost and reliability have been established.

The steam engine is a notable offender in wasting fuel, and this type of prime mover has been practically driven from the stationary power field by the steam turbine; which is a vastly more economical machine. Approximately one-third of the coal burned on steam locomotives is chargeable to "standby" losses, keeping the boiler hot even though the locomotive may not be doing any actual work. More than 60,000 steam locomotives are going through this wasteful cycle of losses every day, and owing to the wide scattering of these motive power units the vast army of firemen employed are under no direct supervision. Furthermore, there is a tremendous waste in carrying coal from the mines to the coaling depots and then transferring it again over the road in the engine tenders.

While it must be conceded that fuel economy alone cannot justify the expense of electrification, this subject is timely and important and, by all means, should receive careful consideration.

The St. Paul Locomotives

Mr. Armstrong pointed out the advantages of such a powerful and flexible type of motive power as the gearless electric locomotive which has recently been put into operation on the Cascade division of the Chicago, Milwaukee & St. Paul Railway. This locomotive is capable of pulling 12 steel cars, weighing 1,000 tons, up the ruling grade of 2.2 per cent, at the rate of 25 miles per hr., without any assistance, and with the same train is capable of running from 60 to 65 miles per hour on level track. While the Mallet compound steam locomotive is able to give great tractive power it can only be done at the sacrifice of speed. To move freight over the road with the same speed that the electric locomotive can do it, two of these enormous steam locomotives would be required. Furthermore, the electric locomotive can be maintained at considerably lower expense than any steam locomotive of equal capacity. Even under the present high prices the St. Paul freight locomotives are being kept in repair for approximately 13 cents per mile, whereas the Mallet engines are costing from 30 to 50 cents.

With regard to future electrification Mr. Armstrong pointed out that the subject is no longer an experiment with new and untried apparatus, but that on the contrary installations along the same lines as the present development are practically assured. It is altogether unlikely that any great fundamental changes will be made. There will of course be changes in some of the details, but nothing that would call for the untimely retirement of present existing electric locomotives as are used on the St. Paul.

Transportation Requirements

In his paper F. H. Shepard of the Westinghouse company broadly reviewed the transportation requirements of the country, bringing out the fact that the success of all industries depends upon the free and expeditious movement of railroad traffic. For the last dozen years the growth of transportation facilities has been greatly arrested. Railroad operation in America has established its own standards, and the American railroad operator has developed methods of operation which are far superior to those used in other countries.

One of the greatest losses of the transportation business is the fact that the steam locomotives are inactive such a large portion of the time. From actual records of engines the following information was obtained: Freight locomotives were in service 35 per cent of the time, in the engine house 50 per cent. Passenger engines were in road service about 25 per cent of the time, in the engine house 65 per cent. Switch engines were in service about 55 per cent of the time, in the engine house 42 per cent. The remaining time of all classes, the records show as being spent in terminals in readiness for service.

Mr. Shepard stated that the traffic of the country doubled about every 12 years, and unless facilities were increased to move this traffic expeditiously the burden resulting from congestion and inability to do this would be augmented each year. Such facilities must be provided in advance of the actual needs without too much concern as to their immediate financial return. This idea is not altogether at variance with the present practice on railroads, and few, if any, improvements in the way of additional trackage and expensive terminals can show any immediate returns for the capital invested. In Mr. Shepard's opinion electrification is a physical means through which the most can be secured from the railroad plant, and this for the fact that more power can be used to move a ton and more tons can be hauled in a single train than is possible with the use of steam locomotives. The possibilities of electrified operation have not yet been visualized and this is largely due to the newness of the tool to those who are responsible for our railroad operation and who are familiar with that particular method of operation that has been determined by the limitations in the use of steam locomotives. Mr. Shepard stated that he looked forward to the use of 10,000 kw. for the propulsion of single trains and in some cases very much more than this.

Mr. Shepard concluded his paper by saying that the maintenance of efficient production and distribution of electric power was a business and a science by itself and that the best economical interest of all would be served when the power consumed by railroads was generated by power companies. When those who are responsible for our railroad operation become more familiar with the possibilities of electrification and when the power companies come to more clearly understand the requirements of the railroads in supplying power the electric locomotive will come into more extensive use and eventually the advantage of electrification will be so great that the question of saving fuel by using electric power instead of steam will be looked upon as a by-product.

Alternating Current Theory and Practice

A Brief Practical Review of Basic Principles Prepared for Railroad Electrical Workers

By O. C. Callow

VI. Capacity, Reactance and Impedance

ALL alternating current circuits contain, to some extent, what is known as *capacity*. That is to say the circuit has a certain capacity as a condenser. The chief function of a condenser on a circuit is to store up energy for subsequent use. When a condenser is connected into a circuit the current flows in and out, charging the condenser in alternate directions. As the current flows in at one side and out at the other, the condenser becomes charged, and tends to discharge itself by setting up an opposing electrical pressure. This opposing pressure rises at the same time as the charge increases. Thus it can be said that a condenser connected on an alternating current circuit will assist the current to rise to its maximum value sooner that it would without the condenser. This effect, it will be noted, is exactly opposite to that caused by induction in a circuit, inductance holding back the current from reach its maximum value.

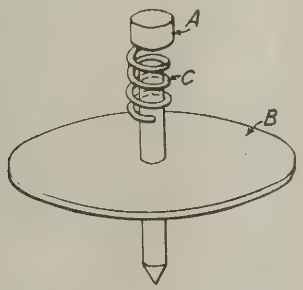


Fig 1—Analogy Explaining Effect of Capacity in Alternating Current Circuit

The following analogy can be used to better illustrate the effect of capacity in a circuit. The disk in Fig. I is supported on a vertical shaft, and has a spiral spring attached in such a manner that if the cap *A* be twisted alternately in one direction and then in the other the disk *B* will follow its motion. After a few turns have been made, however, owing to the resiliency of the spring *C*, the disk *B* will rotate in advance of the twisting force of *A*. The spring *C* will represent the capacity of the circuit while the rotation of the disk *B* will represent the alternating current circuit. We thus find that the spring or capacity of the circuit has caused the current to reach its maximum before the applied power or voltage at *A*. It can therefore be said that the current is *leading* the voltage which is the effect of capacity in an alternating current circuit.

Another method of expressing capacity in an alternating current circuit is the measurement of the amount of electricity stored in it when there is no potential difference in the circuit and therefore no current flowing. Again, if there were no capacity in an alternating current circuit and the circuit was opened, no current could flow through its conductors. If a condenser were connected at the break in the circuit, current could be produced, since the condenser does not hinder the flow of current in the metallic portion of the circuit. The alternating current will produce a continual surging of electricity backward and forward from the plate of the condenser around the metallic portion of the circuit. The actual current does not flow through the condenser itself, there being no flow between the plates.

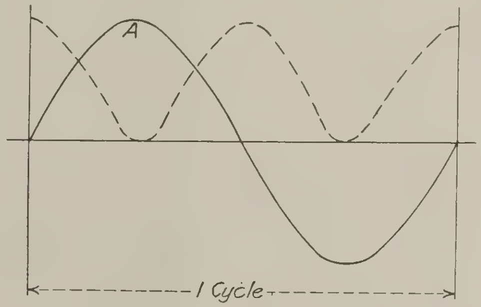


Fig. 2—Showing Relation Between Current Curve and Capacity

The relation of capacity in the circuit to the current can be determined by referring to the current wave shown in Fig 2. Curve *A* shows a wave of the current in the circuit. At the beginning of the cycle this current is zero. At this time, however, the condenser will be fully charged as shown by the dotted lines. At the end of a quarter cycle the current in *A* is at maximum and the condenser completely discharged. As the current again falls to zero the condenser receives another charge, reaching full charge at the end of half a cycle, when the current in *A* is again zero. This will continue throughout the whole cycle. It can thus be said that the maximum charge of a condenser is equal to the average value of the current, multiplied by the time of change which is a quarter cycle.

In practice, capacity must be considered when operating long overhead transmission lines at high voltage. The lines themselves form a condenser of very large capacity, the effect of which is to sometimes boost the voltage at the end of the line higher than it is generated at the power station. This capacity represents a large loss, if the lines are left in circuit when no current is flowing over them, since the charging effect of the condenser will have to be supplied by the power house, although no return is being made for same, since the consumers' meters will show no readings.

Lag and Lead

It has been shown in a previous article that inductance in a circuit tends to prevent the current rising to a maximum or falling to zero. The effect of this, upon the relation between the current and voltage in the circuit is to make the current *lag* behind the voltage. This can be understood by referring to Fig. 3 (a) which represents the current and voltage curves produced by an alternating current generator whose connected load contains no inductance or capacity. In this case the current and voltage will reach a maximum and zero at the same instant and will be said to be in "phase." The curves in Fig. 3(b) represent the effect of connecting an inductive load in the generator circuit. The current curve will have dropped behind the voltage curve and will be said to be *lagging*. The amount of lag is expressed in degrees, since the curves are produced during one cycle of the generator. The current in Fig. 3(b) will have a lag of 30 degrees.

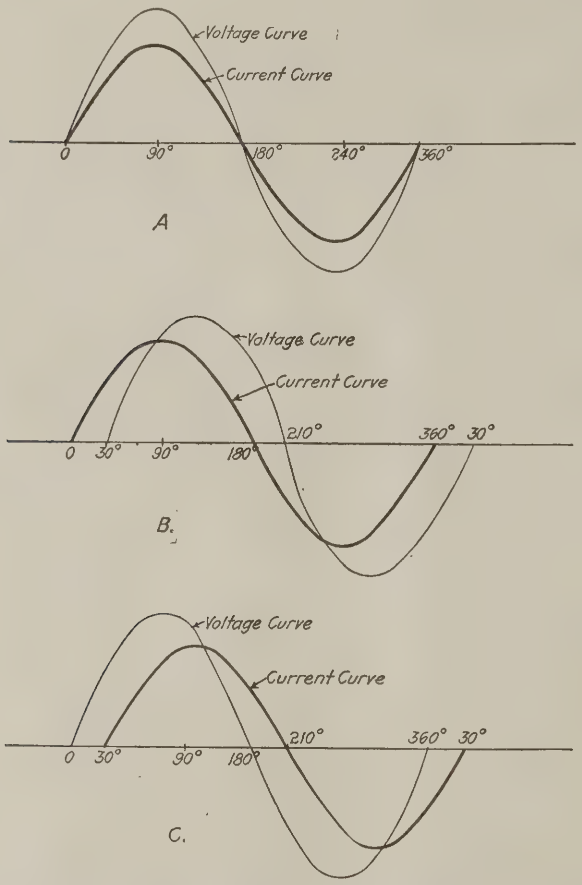


Fig. 3—(A) Curves Showing Current and Voltage In Phase
(B) Current Curve Lagging 30 Degrees Behind the Voltage Curve—30 Degrees out of Phase
(C) Current Curve Leading 30 Degrees Ahead of the Voltage Curve—30 Degrees Out of Phase

The above performance can be explained by considering the following analogy. Fig. 4 represents a locomotive driving wheel and crank which is driven by the piston of a steam cylinder. If the bearing block on the connecting rod is badly worn the piston will commence to travel towards the driving wheel before the wheel revolves. When the slack has been taken up in the block the wheels will revolve. The amount of travel which the piston makes to overcome the slack will represent the lag, which is equivalent to the current lagging behind the voltage when inductance is in an alternating circuit. The lost motion can be measured on so many degrees of the circumference of the driving wheel.

It has been shown above that when an alternating current circuit contains capacity, the effect is to make the current reach its maximum and zero values sooner than the voltage. This will cause the current curve to be ahead of the voltage curve as shown in Fig. 3 (c) and the current will be said to lead the voltage.

Reactance

The word reactance when used without a prefix generally means inductance reactance, which is the inductance of a circuit measured in ohms. It should be distinguished from ohmic resistance as the resistance of a wire will remain the same when the voltage is constant whatever form it is wound in. Thus a straight wire 100 yds. long will have the same ohmic resistance as if it were made up into a small coil. However, when an alternating current is passed through the wire, we have seen that the form in which the wire is wound has much to do with its inductance. It is therefore necessary to keep these two effects separate and thus the term reactance is used.

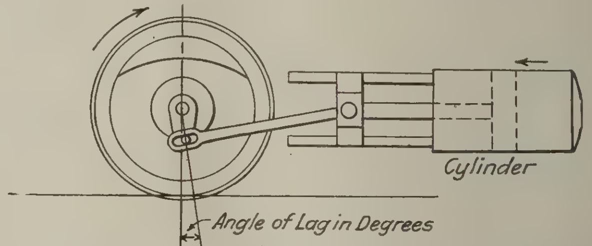


Fig. 4—Analogy Explaining Current Lag in Alternating Current Circuit

When expressing the effect on a circuit caused by capacity, the term capacity reactance is used, meaning the reaction in the circuit due to capacity.

Impedance

The term *impedance* can be defined as the *total* opposition in an alternating current circuit to the flow of current. It is made up of ohmic resistance, inductance reactance and capacity reactance. In practice it is stated that a transformer has a certain impedance, meaning the resultant of the three above effects. Impedance is represented by the following equation:

$$\text{Impedance} = \sqrt{\text{resistance}^2 + (\text{inductance reaction} - \text{capacity reaction})^2}$$

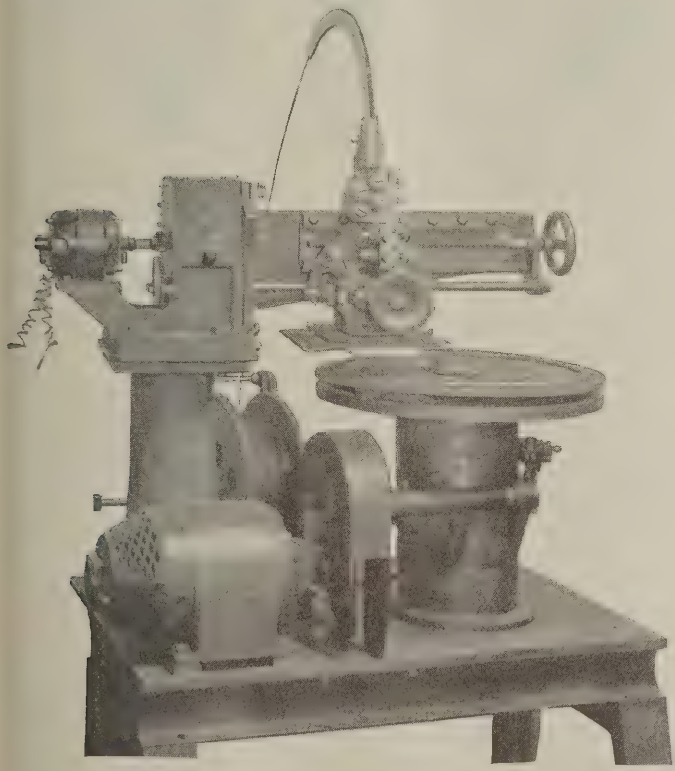
Inasmuch as inductance and capacity have opposite effects upon a circuit they can be subtractive from one another.

The Automatic Arc Welding Machine*

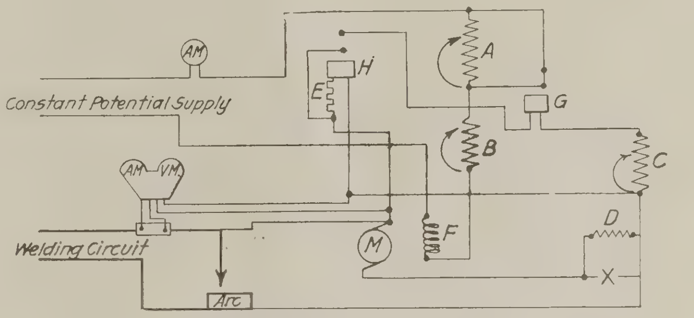
Uniformity of Welds Secured at Greatly Increased Speeds and with Marked Reduction in Cost

By H. L. Unland
Power & Mining Dept. General Electric Company.

THE automatic arc welder is a device for automatically feeding the metallic electrode wire into the welding arc at the rate required to hold a constant arc length. Under these circumstances the electrical conditions are kept constant and the resulting weld is uniform and its quality is thereby improved. It is possible with this device to weld at a speed of from two to six times the rate possible by skilled operators welding by hand. This is partly due to the stability of the welding conditions and partly due to the fact that the electrode is fed from a continuous reel, thus eliminating the changing of electrodes. The automatic welder is adaptable to practically any form of weld from butt welding of plates to the depositing of metal on worn surfaces such as shafts, wheels, etc.


The Welding Head is Supported on a Pedestal and the Work Clamped to a Small Table Which is Revolved at the Proper Speed by Means of a Small Motor

Everyone who has made any investigation of electric arc welding has noted the wide variation in results obtained by different welders operating, as nearly as can be determined, under identical conditions. This also applies to the operations of a single welder at different times under identical conditions. These variations affect practically all factors of welding such as speed of welding, amount of electrode consumed, etc. When indicating instruments are connected to an electric welding circuit, continual variations of considerable magnitude in the current and voltage of the arc are at once noticed. This same condition was found some years ago in the cutting of steel plates by the gas process and when an equipment was devised to mechanically travel the cutting torch over the plate, a series of tests to determine the maximum economical speed, gas pressure, etc., for the various thicknesses of plate were made. The result was that the speed of cutting was increased to as much as four or five times the rate possible when operating under the unsteady conditions incident to hand manipulation of the torch. Further, the gas consumption for a given cut was found to be decreased very greatly.



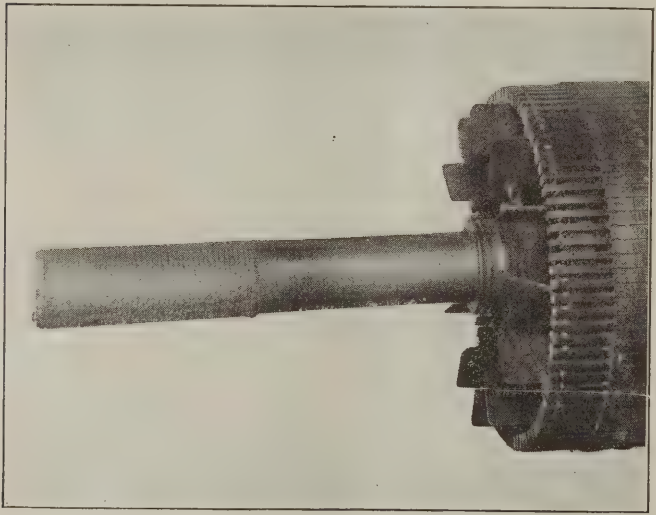
Simplified Connection Diagram of Automatic Arc Welding Control. (A) Regulating Rheostat in Motor Field Circuit Controlled by Arc Voltage Regulator G; (B) Adjusting Rheostat in Motor Field Circuit; (F) Feed Motor Field Winding; (M) Feed Motor Armature; (D) Resistance in Motor Armature Circuit to Adjust Speed When Starting Feed Motor Before Arc is Struck; (G) Arc Voltage Regulator; (E) Permanent Resistance; (H) Over-Voltage Relay

As a result of these experiences an investigation was started to determine what could be done in controlling the feed of the electrode to the electric arc in a metallic electrode welding circuit. An electric arc is inherently unstable, the fluctuations taking place with extreme rapidity. In any regulating device the sensitiveness depends on the percentage of variation from normal rather than on the actual magnitude of the values, since these are always reduced to approximately a common factor by the use of shunts, current transformers, or resistances. The characteristics of practically all electric welding circuits are such that the current and voltage are interrelated, an increase in one causing a corresponding decrease in the other. Where this is the case it will generally be found that the percentage variation of the voltage from normal when taken at the customary arc voltage of 20, will be approximately twice the percentage variation in current. Further, an increase in arc voltage, other conditions remaining the same, indicates that the arc has been lengthened, thus giving the metal a greater opportunity to oxidize in the arc, with a probability of reduction in quality of the weld. The automatic welder utilizes the arc voltage as the basis for regulating the equipment. The rate of feeding the wire varies over a wide range due to the use of electrodes of different diameters, the use of different current values, etc., caused by details of the particular weld to be made. The simplest and most reliable method of electrically obtaining variations in speed is by means of a separately excited direct current motor. Thus the operation of this equipment is limited to direct current arc welding circuits but these may be of any established type, the variations in characteristics of the welding circuits being taken care of by proper selection of resistors, coils, etc., in the control.

---

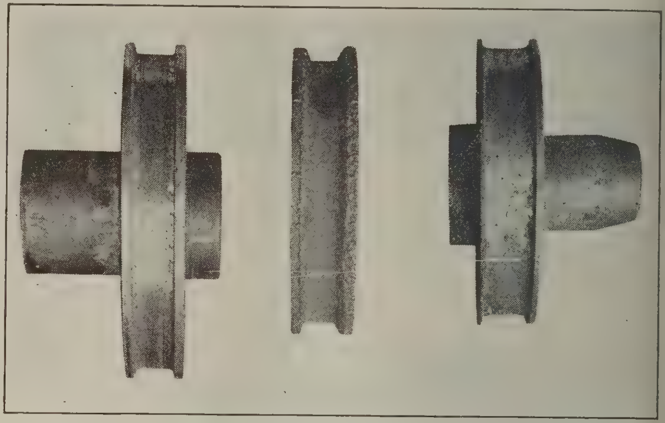
*From a paper read before the American Welding Society.

The welding head consists essentially of a set of rollers for gripping the wire and feeding it to the arc. These rollers are suitably connected through gearing to a small direct current motor, the armature of which is connected across the terminals of the welding arc. This connection causes the motor to increase in speed as the voltage across the arc increases due to an increase in the length of the arc and to decrease in speed as the voltage decreases due to a shortened arc. A small relay operating on the principle of a generator voltage regulator is connected in the field circuit of the motor which assists in the speed control of the motor as the arc voltage varies. Rheostats for regulating and adjusting the arc voltage are provided by means of which the equipment can be made to maintain steadily an arc of the desired length and this value may be varied from over twenty to as low as nine volts. No provision is made for adjustment of the welding current since the operation of the automatic machine is in no way dependent on it. This adjustment is taken care of by the control panel of the welding set. This may be either of the variable voltage or constant potential type but it is necessary to have a source of constant potential to excite the fields of the feed motor. It may be possible to obtain this excitation from the welding circuit but this is not essential. The voltage, of both the welding and constant potential circuits is immaterial provided it is not too high, but these voltages must be known before the proper rheostats can be supplied.



Worn Shaft of Induction Motor Built Up By Automatic Arc Welding

Observation of indicating meters on the control panel show that the current and voltage are practically constant, but it should be remembered that all indicating meters have a certain amount of damping which prevents the observation of variations, which are extremely rapid or of small magnitude. The resultant value as read on the instrument is the average value. Oscillographs taken with short arcs show that notwithstanding the fact that the indicating meters show a constant value, a succession of rapid short circuits is continually taking place, apparently due to particles of the molten wire practically short-circuiting the arc in passing from the electrode to the work. This is indicated by the fact that the voltage curve fell to zero each time and accompanying each such fluctuation, there was an increase in the current. It was found that with the shorter arc the frequency of occurrence of these short-circuits was considerably higher than was the case when the arc was increased in length. To all appearances the arc was absolutely steady and continuous and there was no indication either by observation of the arc itself or of the instruments that these phenomena were occurring.



Worn Crane Wheel Flanges Repaired By the Automatic Process

The following tables give an idea of the speed of welding which may be expected but it should be borne in mind that these figures are actual welding speeds. It is necessary to have the material properly clamped and supported and to have it travel past the arc at a uniform speed. In some cases the figures given have been exceeded and under certain special conditions it may be desirable to use lower values than those given.

SEAM WELDING

Thickness in inches	Amperes	Speed, inches per minute
.040	45 to 50	20 to 30
1/16	50 to 80	15 to 25
⅛	80 to 120	6 to 12
3/16	100 to 150	4 to 6

BUILDING UP (WHEELS OR SHAFTS)

Dia. or thickness, inches	Electrodes, dia., inches	Amperes	Speed, inches per minute	Lb. deposited per hour
Up to 1 in.	1/16	60 to 90	11 to 13	1.04-1.56
Up to 3 in.	3/32	90 to 120	6 to 8	1.59-2.1
Over 3 in.	⅛	120 to 200	4 to 6	2.5-4.5

On account of the great variation in conditions under which this equipment may be used it is provided with a base which may be bolted to any form of support. It may be held stationary and the work moved past the arc or the welding head may be moveable and the work held stationary. These points will be dictated by the relative size of the work and the head, and the equipment which may be available. Provision must be made for traveling one or the other at a uniform speed in order to carry the arc along the weld. In the case of straight seams a lathe or planer bed may be utilized for this purpose and for circular seams a lathe or boring mill may be used. In many cases it will be found desirable to use clamping jigs for securely holding the work in shape and also to facilitate placing in position and removal from the feeding mechanism.

The principal field for this device is where a considerable amount of welding is required, the operations being a continuous repetition of duplicate welds. Under these conditions one can economically provide jigs and fixtures for facilitating the handling of the work and the clamping. Thus can be reaped the benefit of the increased speed in the actual welding which would be lost if each individual piece had to be clamped and handled separately.

The Wasted Millions in Material Handling

Tremendous Savings Possible By the Use of Electrically Operated Equipment at Terminals

By Harwood Frost

ONE of our favorite topics of conversation of recent months has been the high cost of living—we have been told that it is caused by profiteering, by high labor costs, by underproduction, by the excess profits tax, by inflation, extravagance and other causes, most of which can be traced directly or indirectly to the war. No one or two of these factors can be said to be *the* cause of high prices. They, with many others, are all contributory, and among these other factors, are the wastes involved in the traffic in goods, or in the handling of materials in transfer.

The railroads and the water routes are the lanes over which the traffic passes, but the ends of these lanes are our railroad and marine terminals, and through them passed goods representing last year a commerce of nearly ninety billions of dollars, representing a per capita expenditure of $806.

It has been stated by authorities that of this expenditure, about *one-third,* or a total of between 25 and 30 billions of dollars, can be traced to inefficiency and preventable wastes in our methods of handling materials in transfer from producer to consumer. This enormous sum—a sum much greater than the total issue of Liberty Bonds—is incorporated in our expenditures by a system of multiplication and addition in the progress of commodities from the source, through the hands of the middleman, to the consumer. It plays an important part in making up our present high cost of living, largely because of indifference of shipping interests, political influence and ignorance of the general public to the conditions which exact this burdensome and unwarranted tax.

Waste in materials-handling methods hampers production and there cannot be any doubt that this unnecessary tax of between 25 and 30 billions of dollars has a most serious effect on one of our great problems—underproduction.

The handling of commodities is purely a non-productive expense. No amount of lifting and hauling increases the quality or the intrinsic value of the article. The ultimate price depends on transportation and handling. As the goods pass from producer to consumer through the hands of wholesalers and jobbers each adds his profit in addition to his expenses; as the bags or other packages are loaded into cars or boats, unloaded and trucked across docks and warehouses, piled for storage and otherwise handled, each handling increases the ultimate cost.

Now, assume that a farmer gets a dollar for a bushel of potatoes. The commission merchant pays 25 cents to get them to market; he adds 100 per cent to cover transportation, wastage and profit, selling to the retailer at $2.50; the retailer adds 50 per cent to cover his expenses and profit and sells to the consumer at $3.75. In the original transportation to the city market, assume a waste of 10 cents due to the inefficient handling methods; the commission merchant's 100 per cent multiplies this to 20 cents and the retailer's 50 per cent adds another 10 cents, so the consumer pays an unnecessary tax of 30 cents, or three times the original waste.

Take the case of sugar—it grows in Cuba, is carried in the form of cane to the grinding mill, is processed into raw sugar, packed in bags and piled in the warehouse. There are no sugar refineries in Cuba, so the bags are transferred to cars and hauled to the port where they are again piled for temporary storage. They are then transferred to ships and carried to one of the American ports, unloaded and piled, lightered or otherwise transferred to the refinery, unloaded and piled; then passed into the refinery, and processed into refined sugar, packed in 100-pound bags, trucked to warehouse and piled; later when sold to jobbers, these bags are transferred to cars, hauled to Chicago or some other city, unloaded at a warehouse and again piled. Finally, they are loaded into trucks and distributed, and when you buy your little package at the grocery, you pay in proportion for all of these handling processes and all the waste, multiplied many times.

This waste is multipled and then added to by the terminal piling and loading method—the total is multiplied and again added to by the refiner, and a fourth multiplication of the total and an addition is made by the jobber, etc., and the consumer is handed the bill for the whole thing. What this total is in such a large industry, no man can tell, but it is well known that since the advent of mechanical handling methods in Cuba, hundreds of men who formerly did *non*-productive work now produce, and one man does more non-productive handling than was formerly done by ten men.

Now consider our American cotton industry—our cotton is treated in a barbarous manner. It is first hauled to local stations where it frequently remains for long periods, lying on the ground or in uncovered sheds, unprotected from the weather. The "country damage" resulting from this neglect at the source is shown by the statistics of the United States Department of Agriculture to amount to over $75,000,000 annually. Baling the cotton and the first handling of the bales, cause an annual loss, officially estimated by the American Cotton Association, to be $200,000,000. The cotton is cut, recut, and otherwise abused, then passed from the gin to the compress where it is unloaded, compressed, reloaded, and from there it goes to the re-compress where the process is repeated. It is dragged by hooks, dumped about in the most criminal way and ultimately reaches England in a disreputable condition. At Manchester, practically every bale of American cotton must be opened and re-baled. In our methods of sampling and testing cotton, it is estimated that over 10,000 bales are wasted annually.

The railroads of the United States handle under normal conditions over one billion tons of miscellaneous freight annually, as was shown in the Interstate Commerce Commission report of 1914, the handling of which, not including the rail haul, costs from a few cents up to 50 cents per ton, and in some special cases much more, depending on many varying conditions. It is asserted that from ten to thirty cents a ton can be saved by the introduction of mechanical equipment, which would indicate, at an average saving of even 15 cents a ton, a saving to the railroads of about $150,000,000 a year on each handling. As all this freight is handled at least twice, the possibilities in saving would be double this figure—$300,000,000 per annum. The facts are, however, that much of this freight is handled five, six, seven or eight times, exclusive of the hauling.

And yet there is not one single railroad terminal in the United States completely and efficiently equipped with mechanical appliances for the handling of package freight.

In the marine field, it is estimated that under normal peace-time conditions, considerably over 300,000,000 tons of miscellaneous freight are handled at our seaport terminals every year. The conditions of handling in this field and the costs are essentially the same as in the case of the railroad terminals, so with an average reduction in cost of 15 cents per ton, there would be an approximate annual saving of $45,000,000 on each handling, and as this freight also must be received inward and shipped or delivered outward, the possible saving would be ninety million. Add to this $10,000,000, which is a most conservative estimate of the saving that might be effected in handling the vast tonnage of our inland waterways and lakes, and we have a possible saving of one hundred million dollars a year in the terminal handling of our water-borne commerce.

And yet there is not a single marine terminal in any one of the hundreds of ports in the 5,000 miles of sea coast of the United States, nor a single lake or river port in the thousands of miles of our navigable waterways completely and efficiently equipped for the handling of package freight.

If these figures may be considered as even approximately correct, the railroads can save $300,000,000 every year by improved methods and the steamship and steamboat companies can save another $100,000,000 a year. In other words, the transportation or terminal operating companies of the United States are unnecessarily wasting $400,000,000 of their stockholders' money every year by lack of efficient handling methods.

The savings effected by a properly co-ordinated system of mechanical freight-handling equipment run from 10 to 80 per cent according to the many conditions affecting each particular installation, but 40 per cent may be considered as a fair average. If we assume the average possible reduction of 15 cents per ton in the expense of each handling to be represented by this 40 per cent, then this $400,000,000 would represent an expenditure for labor alone of about a billion dollars a year, which is actually less the amount so expended at our terminals.

Experience has shown that where labor-saving machines of this nature are in fairly continuous use, the savings they effect will repay the investment in from six to eighteen months. From this rough basis we may estimate that the value of the equipment necessary to effect a saving of $400,000,000 a year, repaying its cost in approximately 15 months, would be $500,000,000—only six per cent of the labor investment represented in the annual waste, only half of the actual labor cost of one year, and only two-and-a-half per cent of the amount of Liberty Bonds bought by the American people.

But this is not all—these figures refer to labor only. Add to this possible saving of labor, the savings due to quicker deliveries of goods, the savings due to quick release of cars, ships and trucks, the elimination of damage to packages, the prevention of loss of perishable freight, etc., and you can well realize that any substantial proportion of these combined savings for a single year would be sufficient to pay for the erection and complete equipment of a large number of terminals, and that the elimination of such wastes would mean the transfer of thousands of laborers from non-productive to productive work.

It has been estimated that the average expense of hauling a ton of freight 240 miles is 74 cents, while the average expense of handling the same ton of freight at the terminals is 75 cents, that is, the terminal handling charges equal the freight haul of 240 miles. As an example of the expenses involved in the short haul from New York to Philadelphia by rail—the cost of handling at the terminals is $3.65, and the railroad cost for the 90 mile haul is 27 cents. The terminal expenses are nearly 14 times the rail haul.

It costs as much to deliver a shipment from a freight terminal in New York to the hold of a ship as it does to transport it by rail from Chicago to the New York Terminal. The 1,300-mile marine haul from Havana to Boston is cheaper than the transfer from one pier in Boston harbor to another. It costs more to load a box of canned goods on a car in Chicago than it does to carry it by rail from Chicago to New York. It costs more to transfer a barrel of flour over the wharf and to the hold of a ship in New York than to carry it by that ship from New York to Liverpool. It is said that the waste caused by idleness of motor trucks at terminal points due to inefficient loading methods and congestion is over $250,000,000 a year.

New York, where half the nation's imports and exports are handled, is planning to build a terminal practically devoid of modern materials-handling appliances. New York plans to spend many millions of dollars on docks of exactly the size and type built in the days of the "clipper ship" with no regard to a possible decrease in handling costs to manufacturers and distributors.

But we are all paying our tax for New York's inefficiency in the price of every pound of sugar we eat, every cigar we smoke, every cup of coffee we drink; we are paying for it daily in every dollar we spend. It cannot be said that the terminal problem is a local one that affects New York, Seattle or New Orleans only. It is a national problem that affects everyone of us.

America has invented and manufactured more modern freight handling machinery than any other country in the world, and *uses* comparatively less. Still, we are building up a merchant marine in an effort to compete for the world's trade and at the same time neglecting the very methods that make for the profitable operation of many foreign ports, and that contribute largely to the normal low cost of living in these foreign countries.

Not until our terminals are properly designed with regard to the goods to be handled, and adequately equipped with machinery that will reduce both the time of the cargo and the idle time of the carrier, will we be able successfully to compete with these older, more experienced and more efficient maritime peoples, and only when the general public has been enlightened as to the economic effects of our present wasteful methods, and aroused to the realization of its powers and responsibilities in the matter, will we have efficiency in place of the present chaos, and a terminal system that will be a credit to the engineering ability of the American people and a worthy support of our prospective and much-talked-of mercantile marine.

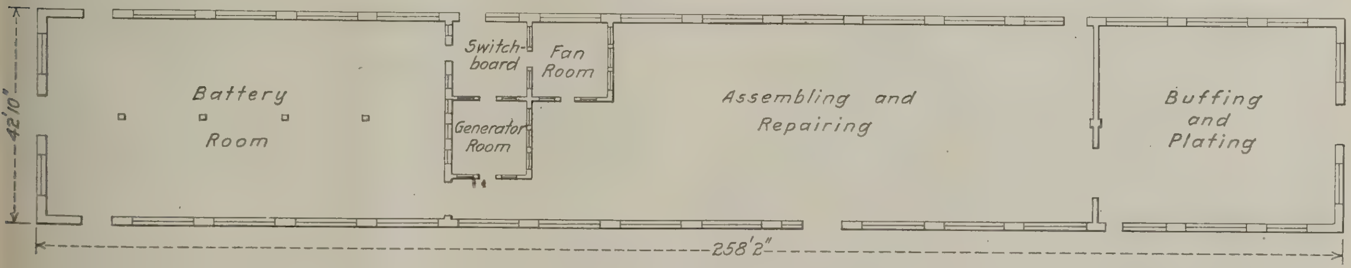
Car Lighting Maintenance on the New York Central

Modern Shop at Collinwood, Ohio, Includes Every Facility for Proper Upkeep of Axle Lighting Equipment

CAR lighting maintenance problems lose most of their complications when they are taken for solution to the big modern repair shop which the New York Central has erected at Collinwood, Ohio. The building was designed in the company's offices and every possible precaution was taken to insure the material best suited for the various purposes being used in its construction. The structure, itself, is 258 ft. long and 43 ft. wide. It is divided into three main compartments, the battery room, the assembling and repair room and a buffing and plating room.

The Battery Room

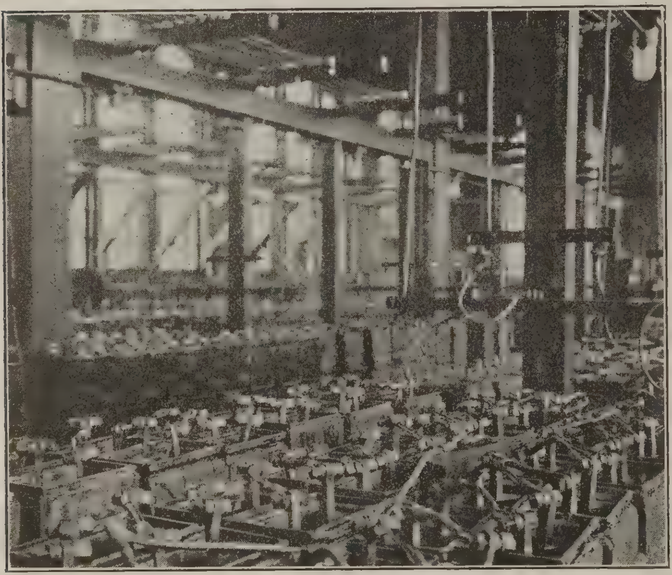
There is perhaps no other portion of such an installation that is of more importance than the battery room. The presence of sulphuric acid and acid fumes necessitated an elaborate construction. The floor consists of 8 in. to 12 in. of cinders, 4 in. of concrete, three layers of 4-ply tar paper and enameled brick laid in ¼-in. of sand. This brick work is also extended 12 in. above the floor on the sidewalls and all joints are poured with hot asphalt. The floor is drained by a complete drainage system, care being taken to eliminate all solid matter from the sewer. A catch or drainage basin of vitrified brick, laid in pitch, is built into the floor so that it catches all solid matter, thus preventing it from entering the sewer. The roof also is different from that on the rest of the building, being constructed mainly of seasoned long-leaf yellow pine beams, with an additional center post to give added strength.



An Outline Sketch of the New York Central's Car Lighting Repair Shop at Collingswood, Ohio

At one end of the battery room provision is made for washing tanks, steaming covers, storing exhausted and fresh acid, and cleaning battery elements. The remaining portion of the battery room is provided with benches for charging and repairing storage batteries. There are five rows of these battery benches, each 48 ft. long; three rows being double benches about 10 ft. wide and two rows being single benches along the sidewalls. The main supporting members of these benches are 4-in. by 4-in. posts which are braced with 2-in. by 4-in. braces. The tops of the benches are made of two overlapping thicknesses of 4-in. by 1-in. tongued and grooved boards. Center posts, 6-in. by 4-in. square and 9 ft. in height, are located at intervals along the line of benches. These posts are used for carrying cross-arms for supporting the lead-covered conductors. All of the surfaces of the interior wood construction are painted with asphaltum paint, and then with an acid proof paint to protect them from the splashing of acids and from acid fumes.

The wiring to the battery room is carried in 2½-in. conduit which terminates in condulets each having a 6-hole porcelain cover. These condulets are built directly into the brick partition between the battery room and the switchboard room. From the condulets the wiring is all open, the conductors being lead covered, supported on cross-arms and fastened with porcelain cleats. The leads are brought down from the cross-arms to the various benches and in order to prevent short circuits from loose hanging terminals a wooden spacer or cleat, 12-in. long, is used to keep the positive and negative leads from coming into contact with each other.



View of Battery Room Showing Charging Conductors on the Cross Arms

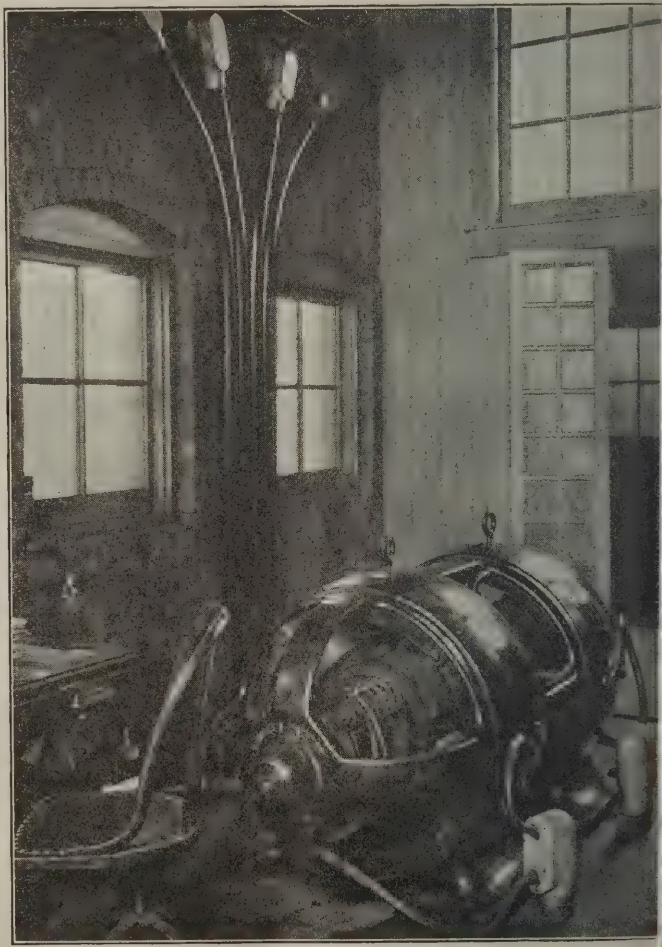
In laying out the lighting of the battery room the two requirements kept in mind were, first, to give good light distribution, and, second, to carefully protect the fixtures after they were installed. Seven lighting circuits are carried from a distributing panel board in the switchboard room in ½-in. and ¾-in. conduit runs. Two rows of five 200-watt lamps and distributing type steel enameled reflectors, equally spaced, are located high under the roof for lighting the shop in general, and five rows of six lamps of 60-watts each are located directly over the five battery benches. The lower lamps are equipped with standard vapor and gas proof fixtures for protection and all of the metal, excepting that in the overhead fixtures, is covered with acid-proof paint.

A General View of the Repair and Assembling Room

Between the battery room and the repair room are located the switchboard room, the motor generator room and the fan room. Power for the motor-generator set is obtained from the main power house, coming in at 440 volts, 3 phase, 60 cycles.

The Switchboard and Connections

The switchboard is energized from the motor-generator set located in the adjacent room. Two 500,000 circular mil, double-braided, rubber covered cables and two No. 8 B. & S. conductors are run in a 3½-in. conduit, and two 400,000 circular mil, double-braided, rubber covered cables are run in a 3-in. conduit between the switchboard and a motor-generator set. The ends of the conduit at both the switchboard and motor-generator set extend about 6 in. above the floor, the necessary bends being made with a radius of 21 in. The ends of the conduit are equipped with bushings which are sealed

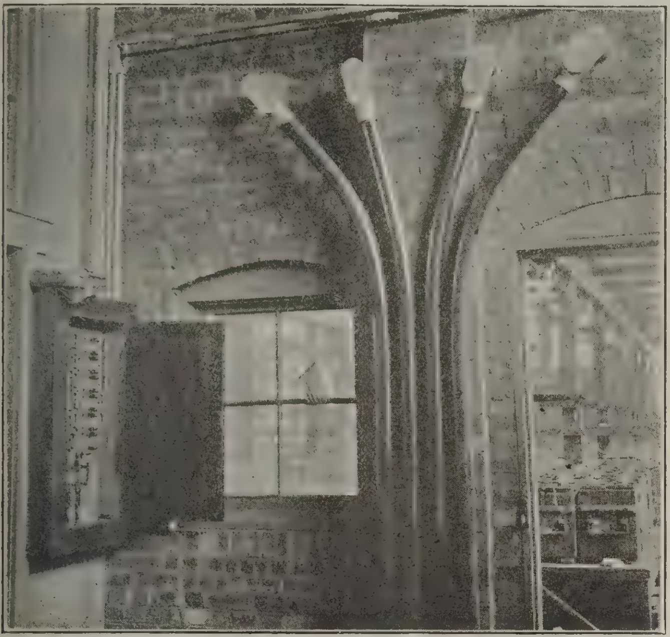


Interior of the Generator Room Showing Charging Set and Con duit Leading to the Switchboard

The switchboard consists of four 2-in. dull black slat panels, mounted on T-bars and angle irons. The general panel controls the current from the motor-generato set, and is equipped with two 400-ampere, 250-vol single-pole, single throw switches, which are connecte to the positive and negative lines of the generator. Abov these switches are mounted a field rheostat for regulating the generator field, a 400-ampere d. c. ammeter, 125-volt d. c. voltmeter and a 400-ampere, 125-volt d. circuit breaker which has reverse current, overload, an no voltage release features.

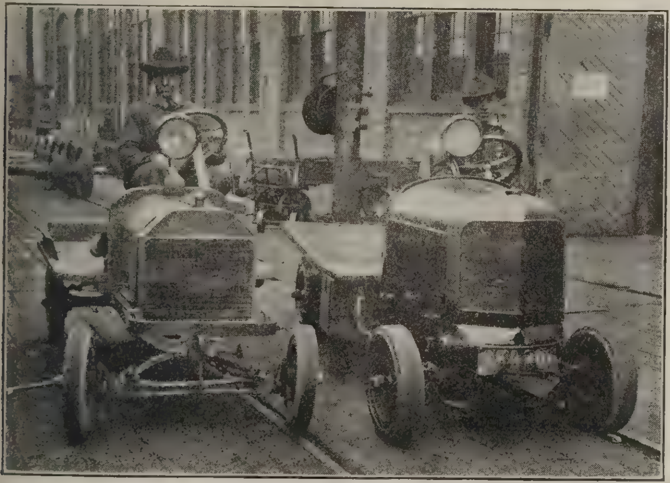
On the feeder panel are positive receptacles connecte to the battery charging racks and yard lines, power receptacles for charging two 32-volt batteries in series, or 64-volt batteries in multiple. In order to prevent confusion and trouble the power receptacles are painted a different color from the charging receptacles.

The remaining two panels are control panels consisting of charging rheostats, selector switches, line switches and voltmeter receptacles. All of the rheostats have radiator fins and pilot type hand wheels.



The 2½ inch Conduit From the Switchboard Entering the Brick Partition Between the Battery Room and the Switchboard Room

On a swinging bracket are mounted three additional meters, two of them being 100-ampere ammeters and the third a 100-volt battery voltmeter. These meters are used for obtaining readings of current and voltage when charging and discharging the batteries.

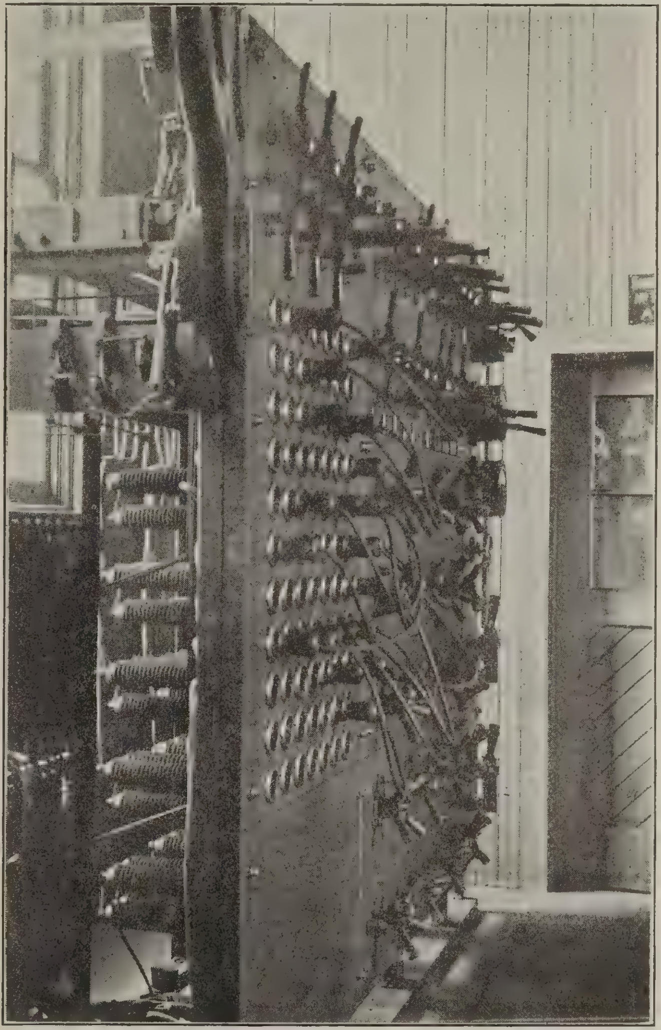


These "Cut Down" Cars, Known as Shop Mules, Are Very Useful in Carrying Heavy Material Between Shop and Cars

One of the features of the board is the utilization of the discharging current of two batteries on test to charge a third battery. This result is obtained by simply closing special, marked switches and the use of portable jumpers in the receptacles.

Repair and Assembling Room

The repair and assembling room is constructed with a concrete floor, brick walls and a specially constructed roof truss to give a large floor area and to eliminate all center posts. The room is large and well equipped for doing such work as winding coils, turning down commutators, transferring materials, lead burning and repairing generators and is fitted with racks and shelves for storing generators and various parts. A store-room is provided, however, where fittings, lamp bulbs, and fixtures are very carefully arranged to prevent breakage. The main feature of the room is the special tables for repairing generators. These individual repair tables are used to save time, simplify the work, and guard against lost parts when repairing machines. The table is constructed of a heavy cast iron center casting with a revolving top and lower sheet iron shelf turned up at the edges to prevent small parts from falling to the floor. When a generator is taken from a car it is placed on one of these tables and taken apart, the armature, pole changer, brushes, bolts, nuts, etc., are all kept on this one table and nowhere else. There are many advantages in the use of tables of this kind; for example, it may be a day, or a month, or even more, before a generator is ready to be re-assembled. Perhaps three or four men worked on a single machine during the



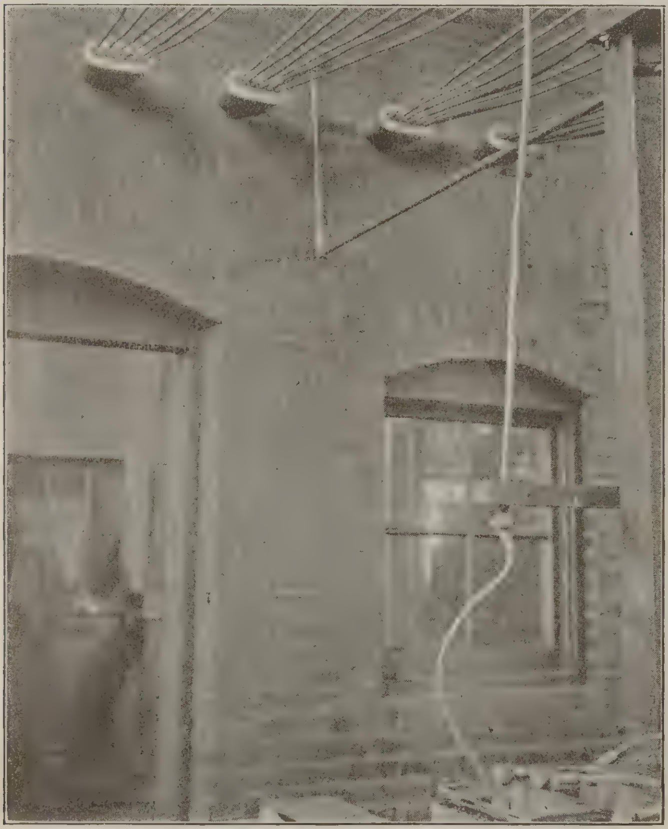
A General View of the Switchboard

course of repair. At any time, however, all parts belonging to this generator are on the table. No time is lost in looking for a brush, a bolt, or a nut, as is usually the case where all generators are repaired on a common bench and the parts of one machine taken to repair a similar one.

The illumination of this shop is accomplished by two rows of seven 1,000-watt Mazda lamps with distributing type enameled steel reflectors. The circuits are controlled from a 10-circuit panel box. All wiring and electric apparatus in battery room, switchboard room and repair room is in accordance with the National Electric Code and the New York Central Railroad's specifications.

Heating and Ventilating

The heating equipment consists of a hot air heater and blower set. The heat is driven under the floor through ducts which have their outlets in the sidewalls of the building. In the case of the battery room, the heater ducts terminate underneath the battery benches along the side walls. This provides some measure of protection to the metal parts of the heater outlets against acid.

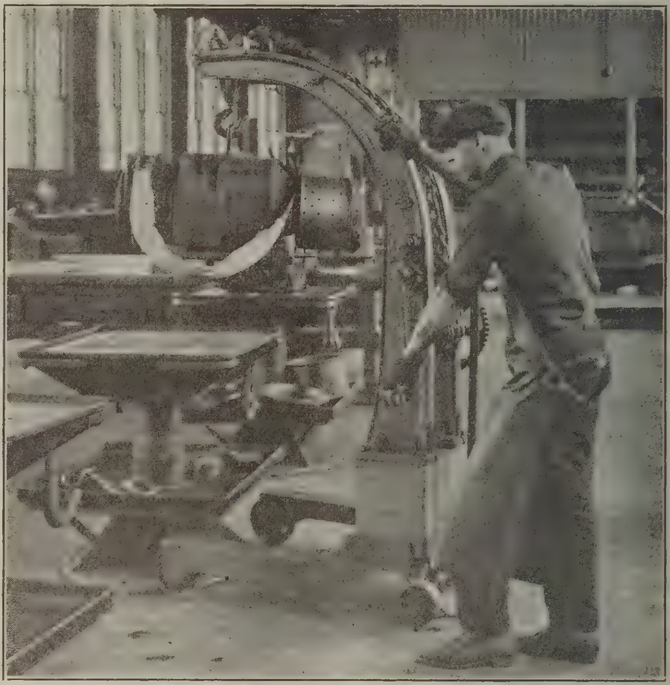


Porcelian Covered Condulets Carrying Conductors From Switchboard to Battery Room

Ventilation is provided by extra large windows and ventilators having an outlet in the roof. The ventilators in the battery room are constructed of cast iron and are 24 in. in diameter, while those in the remainder of the building are of copper, being 36 in. in diameter. This arrangement provides ample ventilation during the summer months, but it has been found that during the winter additional ventilation is required, due to the fact that the doors are closed most of the time. A blower fan is proposed to overcome this difficulty.

The Shop Mules

Two automobiles equipped with wheels of small diameter and otherwise modified, known as "shop mules," are used to transfer all heavy materials between the cars and shop, and also between the various shops and platforms. Batteries, generators and tools are loaded on these trucks and taken right under the cars where they are to be used, or directly to the shops where they are to be repaired. The low vertical height and the short length of these so-called mules make it possible to turn them in a small space and to run between cars, thus enabling them to reach any part of the shops or yards. The shop mules effect a great saving in time or labor and reduce the actual manual labor in the handling of materials to a minimum.



Portable Crane for Lifting and Transferring Material in Shop. The Crane is Lowering a Generator Upon One of the Special Repairing Tables

---

There is no authentic origin of the word "deadhead," which is so frequently used in connection with the transportation business, but the following is an interesting version:

Many years ago the principal avenue of a town passed close to the entrance of a road leading to the cemetery. As this cemetery had been laid out some time previous to the construction of the road, it was arranged that all funeral processions should be allowed to pass along the latter, free of toll. One day, as a well-known physician who was driving along this road stopped to pay his toll he said to the keeper: "Considering the benevolent character of our profession, I think you ought to let us pass free of charge." "No, no, doctor," said the gatekeeper; "we can't afford that; you send too many deadheads through as it is." The story traveled and the word "deadhead" was eventually applied to those who obtained free courtesies.—*Rock Island Magazine.*

Instruction Car Before Newbold Equipment Was Installed

Electrical Equipment on Signal Instruction Car

Service Requirement and Use of Various Devices Lead to Axle Generator as Source of Power

By C. G. Stecher
Signal Instructor, Chicago & North Western, Chicago.

A SIGNAL instruction car on a railroad is somewhat of an innovation, but it has a particular and important service to perform. If the best results are to be obtained the equipment should be complete and adequate for the service. The furnishing of light for illustrated lectures and power for ventilation is a problem which requires special attention, and it is only through the use of numerous devices and from experience with them that the proper methods are finally reached. To equip a signal instruction car with an axle generator may at first seem unreasonable, especially when such a car makes short runs between stops and remains one or more days at each point. Nevertheless, the service requirements of any railroad facility must be known before a correct solution of a given problem can be arrived at. For that reason it is worth while to go into details regarding the service required of a signal instruction car and also relate the difficulties which one road experienced in connection with the equipment used for light and power purposes for such a car. The experimental period, as it may be called, lasted for several years. During this time various electrical devices and circuits were used. The results obtained in many instances proved unsatisfactory until finally an axle generator equipment was installed as one source of power.

The Instruction Car, Its Use and Equipment

In February, 1913, the Chicago & North Western established a system of instruction pertaining to railway signaling, in charge of a signal instructor, whose duties were to travel over the railroad system with an instruction car, stopping at practically all points where engine, train and yard-men lay over or are employed locally, explaining to these men as well as to train despatchers, operators, signal-men and others, the meaning of the signal indications in use, and instructing them to observe and obey the signals.

In order to accomplish this, a standard passenger coach was converted into an instruction car, with a lecture room having a seating capacity of 52, living quarters for the instructor and his assistant, an independent heating plant and a dark room for the development of dry plates and the making of lantern slides. In order to exclude the external light insofar as practicable, the glass in the transoms or deck sash of the lecture room was replaced with sheet metal; the window shades were made wide enough so that their sides fitted into the grooves of the window casings in which the rollers of the spring tension bar at the bottom of the shades slide, when the shades are raised and lowered.

The instructions are in the nature of lectures, given at the various points according to schedules posted in advance. All lectures are illustrated by stereopticon slides showing the various types and combinations of signals actually in service and all signal indications on the road. In addition track and signal diagrams are used to explain the operation of signals under actual service conditions.

A combination stereopticon was provided, which permits the showing of opaque pictures as well as lantern slides. At first the lantern was equipped with a 90-deg. hand feed arc lamp; the current for which was obtained through connections to the local electric light or power circuits. If power was not available an oxy-hydrogen gas-making outfit and burner furnished the light, the gas being made as required. Two rheostats were used for the arc light, one for 110-volt and the other for 220-volt circuits. A 440/110 volt transformer was also provided for use at points where the railroad plants were equipped to furnish alternating current at 440 volts. The car was therefore fitted with all the necessary apparatus for the stereopticon.

During the first tour over the road it was found that at many of the points visited there was an electric light circuit, but the wire or wiring, meter or transformer was of such small capacity that it was not safe to operate the arc lamp, which required 15 to 20 amperes at 40 volts in addition to the original outside load on the circuit. Consequently the gas outfit had to be used, as it was not at all practicable to have a special connection made by the local electric company for one or two days' service. However, it occurred to the instructor that the 4-to-1 transformer might be changed to work also as a 2-to-1, so that when used on 110-volt circuits, approximately 55 volts could be obtained from its secondaries, and thereby reduce by nearly 50 per cent the current drawn from the 110-volt lines. Without the transformer, resistance was required in series with the circuit to reduce the line voltage to 40 volts. A test was made accordingly, which proved successful. The transformer was therefore connected permanently with two double pole double throw switches, so that when a change had to be made from alternating to direct current, or vice versa, it could be done by properly manipulating the switches. The wiring is shown diagrammatically in Fig. 1.

Referring to the circuit, it will be observed that the center leads of the transformer were brought into the cabinet containing the switches, and connected to binding posts *P* and *P′*. The reason for this arrangement was that at a few points the car had to receive power from 220-volt alternating current circuits, which made it necessary to provide some quick means of changing the car transformer from a 2-to-1 to a 4-to-1. In order to do this the connector *B* was provided. This connector was made of two brass strips, each piece being drilled at one end and slotted at the other. Ordinarily both strips connected the two posts *P* and *P′*. The construction of these strips permitted them being applied so that the slotted ends could be unhooked from *P* and *P′*, and then revolved about posts *P* and *P′* until the slotted portions hooked into posts *X* and *X′*, which were located at the same distance from *P* and *P′*, respectively, at *P′* is from *P*. It was only necessary then to tighten all nuts on the four binding posts, and the ratio of the transformer became 4-to-1, and 55 volts could be obtained from the 220-volt circuit. With the brass strips connected, as shown in the diagram, the ratio of the transformer became 2-to-1, and could be used on 110-volt circuits to obtain 55 volts from the secondaries.

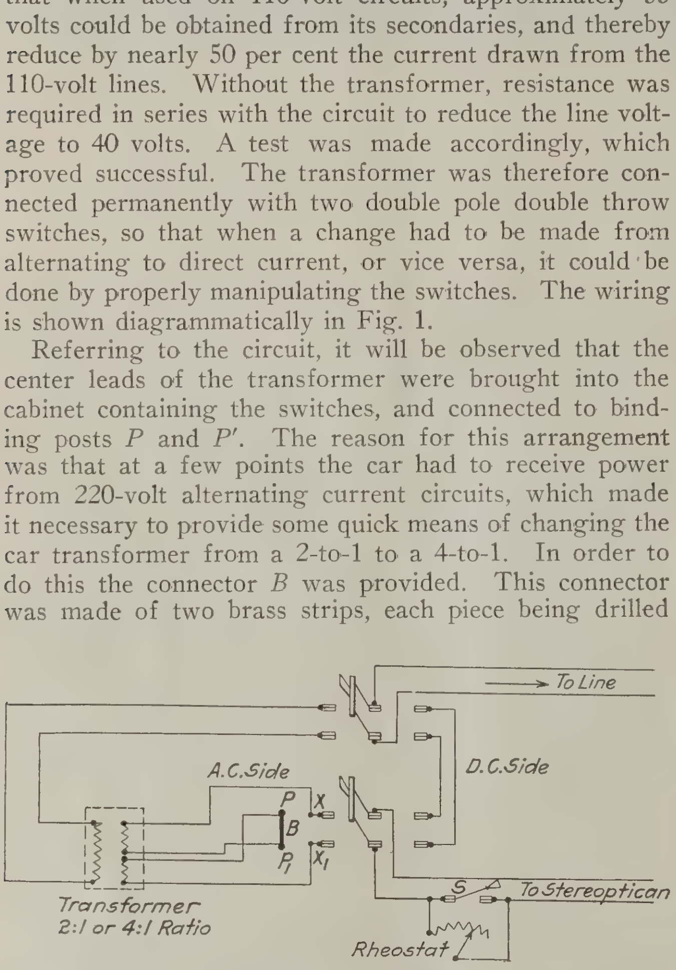


Fig. 1. Switches and Circuits for Connecting the Stereoptican to Transformer or Line

At first a makeshift resistance was used in the 55-volt circuit for regulating the current for the arc lamp; but later, the rheostat, which had been used on 220-volt circuits was rewired. More coils and steps were added in order to obtain greater variation of resistance. This change permitted its use on all voltages, 55, 110 and 220 volts.

The transformer, arranged as described in a previous paragraph, brought about a considerable saving of current, since only a little over 50 per cent of the quantity formerly required was drawn from the line. The greatest benefit, however, derived through its use was from the standpoint of service; that is, the car could be safely connected to any available alternating current lighting circuit, thus insuring electrical energy for the stereopticon, which did not operate as well with the gas equipment. The arc was also found to be steadier and could be maintained in proper adjustment more easily on 55 volts than when operated through additional resistance on higher voltages. In many of the small towns the load on the line caused the voltage to fluctuate very noticeably, particularly during the day, on circuits which supply power to 220-volt industrial motors of fairly large capacity, which operate intermittently. When these were started, especially those located in the neighborhood of the car, the potential drop would be sufficient to cause the arc to break and the light would be extinguished, no matter how careful the stereopticon operator was. It was quite difficult to maintain an arc of even intensity operating from alternating current, particularly when the voltage fluctuated, and at best the alternating current arc produced a dull yellowish light which resulted in an inferior picture.

Nitrogen Lamps for Stereopticon

Because of the objectionable features involved in the use of alternating current for the operation of the arc lamp, the instructor became interested in the nitrogen gas filled concentrated filament incandescent lamps which were then beginning to replace the arc lamp for locomotive headlights. It occurred to him that if adequate illumination could be obtained by the use of such a lamp for headlights, the same lamp, if placed behind the condensing lens of a stereopticon might also give good results. Tests were made with a 32-volt 250-watt lamp, the standard globe then being used for headlights. These tests showed that with 28 to 30 volts this lamp produced a better light, and consequently a better picture than the arc lamp at its best when operated on alternating current.

For several months one of these 32-volt 250-watt lamps was used instead of the arc. It was held and brought into focus by the use of a lamp socket, into which a short piece of ⅜ in. pipe was screwed, which in turn was held in the horizontal carbon holder of the arc lamp frame, thereby obtaining all necessary adjustments, vertical, horizontal, forward and back. This lamp was burned with its tip towards the condensing lens; in other words, in a horizontal position, as was the usual practice for headlights. Some time later, however, a more simple and compact holder was made, which also permitted all necessary adjustments.

Several months later a 110-volt nitrogen lamp with concentrated filament was placed on the market. One of these was obtained for trial. Although the wattage of this new lamp was the same as the 32-volt type, it did not produce the same illumination, even when the latter operated on slightly less than 32 volts. Furthermore, it was found that the 32-volt lamp could be burned either horizontally or vertically with equally good results, whereas it was necessary to burn the 110-volt lamp vertically in order to obtain any illumination of sufficient value for stereopticon use, and it had to operate on full wattage. Even then the illumination was not nearly as satisfactory as that produced by the 32-volt 250-watt lamp. Consequently, whenever the voltage on the line fell below standard, the 110-volt light was not strong enough for daylight use, particularly during the warm weather when, for reasons of ventilation, the external light cannot be excluded to the same extent as during cold weather.

Later a 400-watt lamp of the same specifications was placed on the market and one of these was tried. Then came the 500-watt type of the same construction. The tests conducted on this lamp proved so successful that it was adopted, and is still used as standard for stereopticon use. An intensely brilliant picture is produced by this lamp when burned on full voltage and without any resistance in series with it; in fact, the light is too strong for night use or during cold weather with all the shades down, when the voltage on the line is up to normal. This lamp therefore permits much better ventilation of the car during warm weather without the external light materially interfering with the projection of a good picture. The rheostat mentioned in a previous paragraph is connected in series with the lamp so that the intensity of the light can be regulated as required, according to voltage on the line or external light conditions; or the rheostat can be cut out entirely by closing the switch "S" shown in Fig. 2.

After the 32-volt gas-filled headlight lamp was found to be successful in the stereopticon, the headlight generator of a locomotive was employed to furnish current during lectures at many of the points at which there is no local electric light circuit, providing a locomotive was available at the time of the lecture, thereby eliminating the use of the gas outfit, which is a much more troublesome method of obtaining an illuminant for the stereopticon.

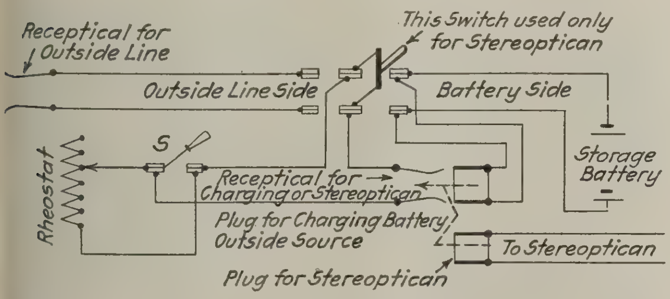

Receptical for Outside Line
This Switch used only for Stereoptican
Outside Line Side
Battery Side
S
Rheostat
Storage Battery
Receptical for Charging or Stereoptican
Plug for Charging Battery, Outside Source
To Stereoptican
Plug for Stereoptican

Fig. 2. Arrangement of Circuit for Charging Battery From Outside Source or for the Operation of Stereoptican from Outside Source or from Battery Supply.

Why the Axle Generator Was Installed

On December 31, 1918, the car completed its sixth tour over the road, and during that time, particularly during the last three years of that period, more stops were added to the itinerary, most of which were for one or two days' duration. Consequently, it became an increasingly difficult problem to obtain light for the stereopticon at all points visited. Furthermore, the gas lamp outfit was never entirely satisfactory, the light being hardly brilliant enough for day use during warm weather and at night oil lamps had to be used for car lighting, which had to be extinguished at the beginning of the lecture and re-lighted with matches whenever needed again. The car was also without power for forced ventilation by means of fans. The instructor began to consider axle lighting equipment with storage battery as a source of light for the car. Inasmuch as such equipments furnish current at the same voltage as headlight generators, and as the latter had proved by trial that a voltage of 28 was ample for a sufficiently brilliant light for the stereopticon, a storage battery of 16 cells should therefore serve the purpose. The important question, however, was, "Would the battery receive sufficient charge between points of visit, to be of material or sufficient benefit to make it worth while to install such an equipment?"

During a period covering months a close check was made of the length of charging periods of such equipments on sleepers, dining and other cars, on such trains on which the instruction car is usually hauled, and from these checks of charging periods the quantity of current available from the storage battery was carefully computed or estimated. These checks and estimates showed that, barring accident to the equipment, which could not be corrected by the instructor and his assistant or the locally employed forces, the equipment would furnish current for practically all one- to three-day stops; in which event the use of the gas lamp and outfit could be entirely dispensed with; it would bring about a material reduction in charges for electric light from local companies and a great deal of labor, in making temporary connections, would be avoided. Furthermore, after making all usual allowances, such as interest on investment, depreciation, etc., a considerable saving could be shown.

A recommendation for the installation of such an equipment was therefore made and it was installed a year ago. Since then the tour over the road for the season has been completed insofar as all short stops are concerned. The experience during that time has proven the equipment to be a decided success, even beyond expectations, for the storage battery was used at more points than were mentioned in the original estimate. The current requirements for car lighting were, of course, maintained at a minimum. The lecture room is illuminated with 15-watt lamps with glass reflectors or shades. These lights are used only for short periods before and after evening lectures, otherwise only a very small amount of illumination is required by the instructor or his assistant for car lighting. Lamps of various voltages are used, 32, 110 and 220 volt, that is, the lamps are changed whenever the voltage is changed.

At all points except two, where the car remains four or more days it is connected to the local source of current and the 110-volt 500-watt lamp is used. At the two points mentioned, the storage battery is used because the local connections are difficult to make. However, the runs between stops are long enough to generate sufficient current for the two-day stops and the succeeding shorter stops.

The generating outfit is a Newbold equipment. Two double pole double throw switches are provided so that the storage battery and axle equipment can be disconnected entirely from the load and also from the line when the car is connected to an outside source. The wiring is also arranged so that the car lighting can be operated from the storage battery and the stereopticon from an outside source, or vice versa, each circuit being entirely separate. Circuits have also been provided so that the battery can be charged from some other source than the axle generator, either from a regular charging outfit, or over local circuits connecting the car to a 110 or 220-volt direct current. In the latter case charging can be done between lectures at a low rate through the rheostat which is used for the stereopticon. The arrangement of this circuit is shown in Fig. 2. Aside from giving this last mentioned arrangement a thorough trial it has not yet been necessary to use it.

Fans for Ventilation

After the car started on its first trip it became apparent that one or two electric fans should be installed for ventilating purposes. Inasmuch as it was not considered practical to provide fans for each of the various currents and voltages, 110 or 220 volt a. c. or d. c., it became a question as to what kind to obtain. The decision resulted in the choice of 16-in. Jandus fans with motors equipped with laminated field cores, wound for 60-volt direct current. These fans will also operate at very nearly full speed when connected directly across the line of a 110-volt alternating current circuit. When these fans are operated on 110 or 220-volt direct current it is necessary to provide some means to reduce the voltage across the terminals of the fan. This is accomplished by arranging a circuit with four 60-watt carbon filament lamps connected in series multiple as shown in Fig. 3. Since the axle generator equipment was installed 32-volt fans have also been provided, so that proper ventilation is assured at all times.

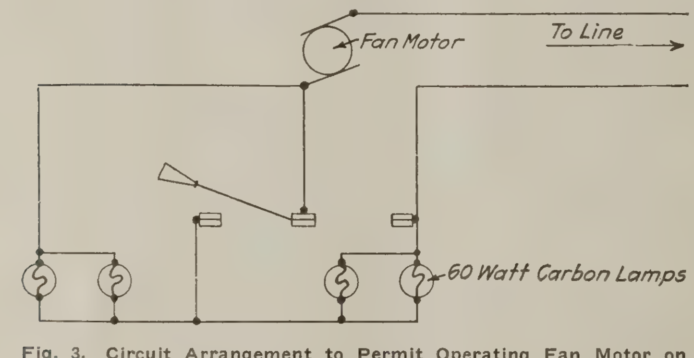


Fig. 3. Circuit Arrangement to Permit Operating Fan Motor on Various Voltages.

From the foregoing it can readily be seen that the once somewhat serious problem of obtaining light for the stereopticon and car, and power for the fans has been practically solved. At no point has it been necessary during the past year to call on outside forces for a connection for light and power.

Calamity howling never helped a good cause, and that is what the railroads are, no matter whether they be operated by the government or by the private owners. —*Clarksburg* (*W. Va.*) *Express.*

More About Welding Electrodes

By E. Wanamaker, Electrical Engineer,
Chicago, Rock Island & Pacific

Regarding the criticism by Mr. Churchward of the Wilson Welder & Metals Co. of the article written by Mr. Pennington and myself on the subject of electrode material for metallic arc welding, I may reply by taking up the questions in order mentioned by Mr. Churchward.

The first item on which exceptions were taken, was that of a statement that practically all of the carbon is lost in passing through the arc, and that the presence of carbon does not seem essential in electrode materials in use, or within the limits of 0.18 per cent carbon and 0.5 manganese, seems to bear this out.

Regarding the loss of the carbon constituents, it has long been known, that an electrode which melts down to relatively large globules will show a considerable percentage of carbon in the weld. If, however, metal is expelled in a uniformly finely divided state, which is necessary for proper fusion and good welding, the loss of the carbon and other constituents will be very great in bare electrode welding.

The fact that most electrode materials bearing carbon much greater than .18% give an unstable arc, resulting in increased brittleness due to inclusion of oxides, etc., will tend to offset the advantages of the small increased carbon content in the weld, also to offset the tendency of the gas formed by the burning carbon to reduce tendency of oxidation by producing a reducing atmosphere. If, however, electrodes are specially treated, that is covered by coating to prevent the unstable arc, and rapid oxidation of the carbon and manganese, the quality of the weld will of course be improved.

Unstableness of the arc is very pronounced in welding of manganese and is thought to be due to the formation of the manganese oxide, and an unstable arc is most always accompanied by an increased area causing the metal to melt down in large globules. Again the chances of ductile weld is greatly minimized, due to slag inclusions, porosity, etc.

It was not stated by the authors that manganese would not add to the strength of the weld, but that in case of bare electrode commercial welding, the advantages gained would probably be offset by some of the phenomena enumerated above.

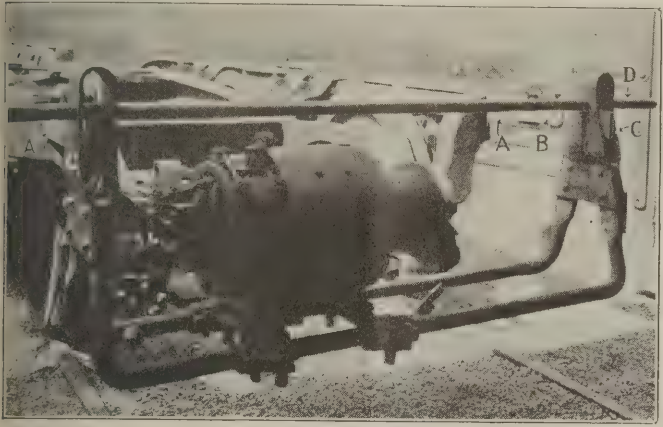
Regarding the question of copper content in the welding electrodes, it has long been known that the inclusion of copper in steel impairs the ductility, but with an attendant increase in tensile strength. Today copper content is not usually specified, except in special cases where it is used with the view of minimizing corrosion.

If Mr. Pennington and myself in the electrode article in question failed to do justice to any make or type of electrode of special merits, it is to be regretted, as it was our sincere intention to present the status of welding electrodes to the best of our ability, as it actually commercially existed.

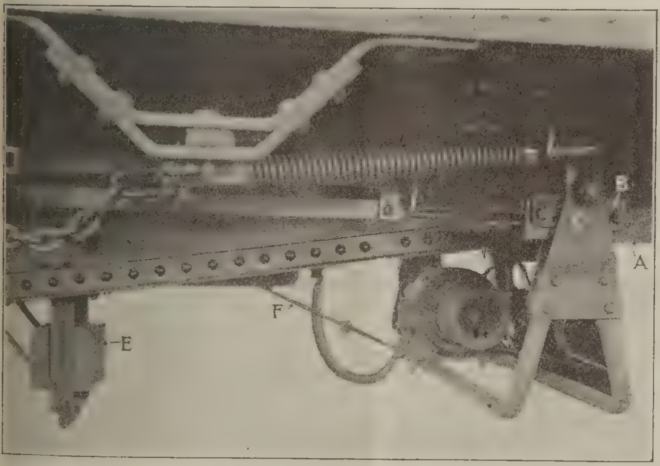
It could hardly be expected that we reveal the special merits of any type of electrodes of which we have no certified data.

Generator Suspension on the Norfolk & Western

The question of whether an axle lighting generator shall be suspended from the car body or from one of the truck frames, is one which promises to remain unsettled for some time to come. If anything there appears to be just at present a slight majority in favor of the body-hung generator, but there are ardent advocates of the truck-mounted machines and there is every indication that this type of suspension will remain on some roads as their standard practice, at least until such time as some type of shaft drive has been developed which is entirely successful. It is usually conceded that the truck mounted generator gives the best performance on those roads which have numerous curves. The Norfolk & Western is such a road as this and undoubtedly that is one of the reasons why the truck suspension, shown in the two photographs, has been adopted.



View of the Norfolk and Western Truck Mounted Generator



An Under-Car View of the Suspension, Showing the Weights Used for Belt Tension

The care with which this truck suspension is assembled is of interest. The extensions *A* are welded to the truck frame and carefully levelled with it. The upper surfaces are made parallel with the frame. The brackets *B* are then put on and the distance from the center of the axle to the center of the bracket is carefully trammed. Pin centers in bracket *B* are set by trams from journal center in truck boxes, after which holes are drilled in extension *A*. No adjustment is provided for changing location of bracket *B* after first set-up. The suspension *C* is hung from the truck extension by the pipe *D* and the generator is put in place. A string with a bob on each end is hung over the pipe and the generator shaft is lined up so that it is parallel with the pipe *D* and the vertical distance from *D* to the center of the armature shaft is made the same on both ends. After these adjustments have been made the generator is mounted from these suspensions by pins through the brackets *B*.

Since the axis of the generator is parallel to the axis through the pins which has been made parallel with the axis of the pulley axle, the armature must necessarily be parallel also to the pulley axle when the truck is standing on straight track and will remain parallel except as inequalities on the roadbed may change the action of the axle slightly.

To remove machine from car, two bolts in bracket *B* are removed on each side, and machine, cradle and brackets are taken off as one piece. In re-assembling, the application of four bolts is all that is necessary, without any re-alinement.

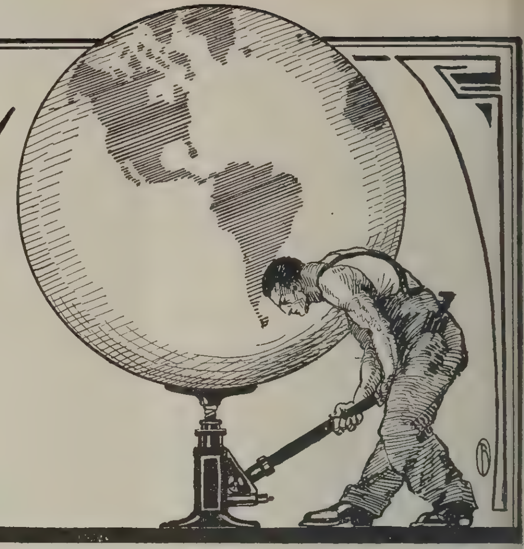
The belt tension is secured by the weight *E* connected through the suspension by the wire cable *F*. This assures a constant pull on the suspension and as the suspension is mounted at the top of the truck while the suspension rods are comparatively low, the angle through which the suspension swings is small, and will have relatively little effect on the belt tension. This suspension has given excellent results in increasing belt mileage. With constant and limited belt tension, 75-ampere machine will give full output with 4-in. belt. The pulleys used have relatively low flanges and it has been found in service that with this method of alining the generator the belt runs in the center of the pulley and the face of the pulley near the flanges is not even kept bright by contact. The first suspensions of this type have given a mileage of more than 90,000 and the first belts applied are still in service. The suspension is covered by patent application.

* * *

Photograph from Underwood & Underwood, N. Y.

Concrete Grain Elevators of Canadian Pacific at Fort William, Ontario

PRACTICAL STUNTS



Water Rheostat for Heavy Load Tests

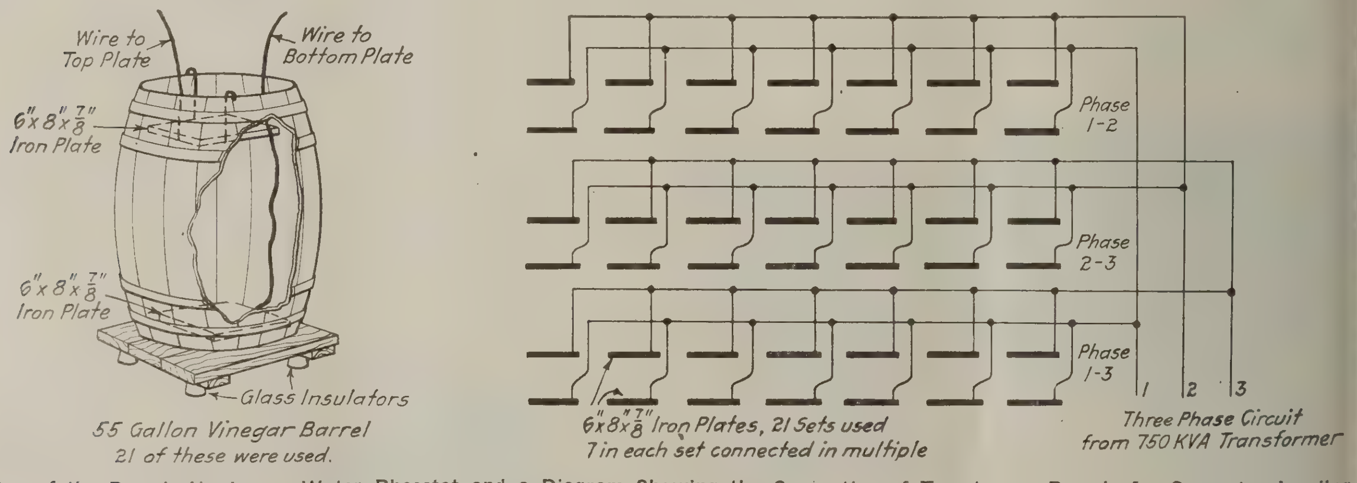
Recently a load test was made on two 1000-kw. 2300-volt steam turbo-generators at a power plant of the Kansas City Terminal, Kansas City, Mo. Both of these units are rated at 1250 kva. with a power factor of 80 percent. There is no means provided to secure power from any outside source, and for this reason only one unit is operated at a time, the other being held in reserve. In emergency cases the idle generator is available to take care of the connected load.

Some time before the test was conducted it was proposed to increase the connected load, but before this was done it was thought advisable to carry on a load test for the purpose of determining the condition of the steam turbine (governor, valves, etc.), while operating under a 1000-kw. load. Inasmuch as the connected load on the switchboard ranged between 500 and 750 kw. the question arose as to how to get an additional load of 250 to 500 kw. for on account of the high voltage (2300 volts) it was out of the question to devise a makeshift arrangement to take care of the increase in load. The difficulty was overcome by using a spare 750-kva., three-phase transformer to reduce the voltage to 220 volts, then by experimenting with water rheostats, consisting of 55-gal. vinegar barrels arranged with metal plates, one at the top of each barrel and one at the bottom, connected across the 220-volt secondary busses, it was found that the arrangement might work out satisfactorily if a sufficient number of barrels were used.

At first three barrels were used, one across each phase, each barrel containing a weak salt water solution. This, however, did not work satisfactorily as the temperature of the water reached the boiling point too quickly to permit the test being carried out to a final conclusion. The next arrangement consisted of 21 barrels, 7 in parallel per phase and with a weaker solution per barrel, about equal to one seventh of the original, at the same time being careful to keep the strength of the solution in all of the barrels as nearly equal as possible, in order to keep the load evenly balanced between the phases.

The illustration shows the arrangement of circuit used, and a sketch of a single barrel showing the connections to 6-in. by 8-in. by ⅞-in. iron plates; one is placed near the top of the barrel and the other at the bottom. The barrels were insulated from the concrete floor by setting them on glass insulators. Three cables, each of 800,000 c.m., were used as feed wires to the barrels, because of the high amperage per phase, approximately 200 amperes.

The load at the power house during the day varied constantly. This variation, between 150 and 200 kw., was due to motors being started or stopped, particularly the 500 hp. elevator motors and the ventilating load at the Union Station. For this reason it was necessary to begin the test early in the morning (2:00 a.m.) since at that time the load was practically stationary at about 500 kw. The additional load of 500 kw. was carried for a period of 30 min., which was a sufficient length of time to determine the condition of the steam turbines. During this period the temperature of the solution in the barrels did not go over 200 deg. Fahrenheit.



55 Gallon Vinegar Barrel
21 of these were used.

6"x8"x⅞" Iron Plates, 21 Sets used
7 in each set connected in multiple

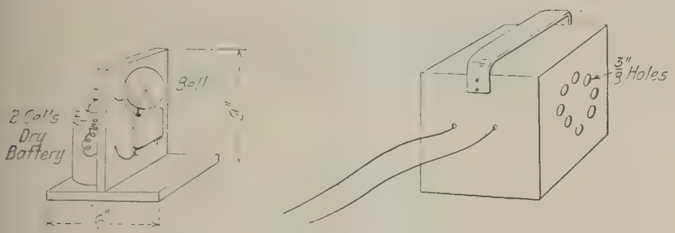
Three Phase Circuit
from 750 KVA Transformer

One of the Barrels Used as a Water Rheostat and a Diagram Showing the Connection of Twenty-one Barrels for Generator Loading

A Convenient Bell Box for Testing

By Jos. T. Hiltz, Long Island Railroad

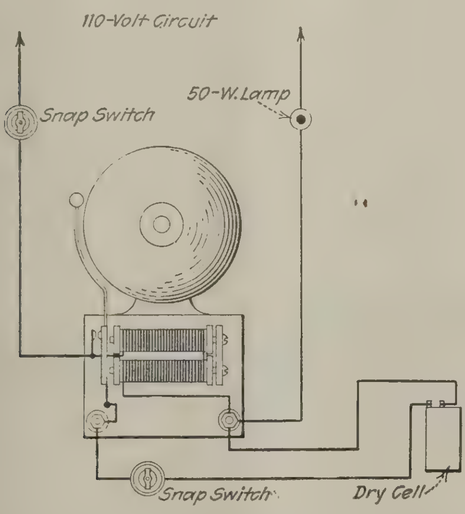
In testing the continuity of any electric circuit there is perhaps nothing that is more satisfactory than a set of dry batteries and an electric bell. The most convenient way to aline these is by placing the batteries and the bell in a box so that they may be carried from place to place when needed. The illustration shows an excellent way in which to arrange two dry cells and an ordinary vibrating bell. The batteries are placed upon a small square piece of board which is connected to a vertical piece in the middle upon which the bell is mounted. This entire unit may be slipped into the box and the lid closed. On the side of the box which faces the bell there is drilled a series of holes to allow the sound of the bell to be heard more distinctly. The testing wires are led out through two holes on one side of the box. Should any mishap occur to the batteries or the bell the inside unit can be easily removed and the repairs made with very little difficulty since all parts are readily accessible.



Sketches Showing Arrangement of Dry Cells and Bell—Also Complete Testing Box

A Power Failure Indicator

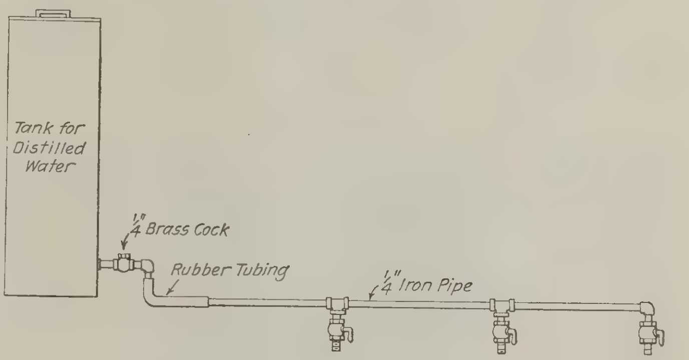
A writer in the *Electrical World* describes a simple and ingenious device for indicating a failure of power supply. When used as an alarm to indicate that the source of energy supply is failed, the scheme illustrated has proved very dependable and inexpensive. An ordinary iron box bell is used, the coils being connected permanently in series with a 50-watt, 110-volt lamp to a 110-volt circuit. One dry cell is connected across the binding posts of the bell. Under ordinary operating conditions, the current through the lamp is sufficient to keep the armature pulled against the pole pieces. When the armature is in this position, no current flows from the cell as the contacts are held open. If the main circuit is de-energized the bell armature springs back against the contact breaker thus closing the cell circuit and causing the bell to ring in the usual way. If it desired to eliminate the hum produced by alternating current the bell may be mounted on rubber or cork.



When the Power Circuit Fails the Bell Will Ring With Current From the Dry Cell

One Method of Filling Edison Cells

Various methods have been devised for supplying water to storage batteries. For a set of 56 Edison storage cells in a permanent location the arrangement shown in the illustration was installed and has been found to be a great covenience. The tank which is made of non-corrosive metal, is located on a shelf two or three feet above the top of the cells. From this tank the distilled water is led through ¼-in. iron pipe along the wall directly behind the batteries. This pipe is approximately 15 ft. long and has three ¼-in. brass cocks evenly spaced along its length. When it is necessary to replenish the cells the cock at the tank is opened and the water allowed to fill the ¼-in. horizontal pipes. The regular Edison refilling nozzle with alarm attachment is attached by a rubber hose to each of the outlets of the horizontal, using the outlet nearest to the cells being filled. The arrangement has proved to be most convenient and most satisfactory.



The Cocks in the Horizontal Pipe Are Approximately 5 Feet Apart

How to Make a Stencil on Glass

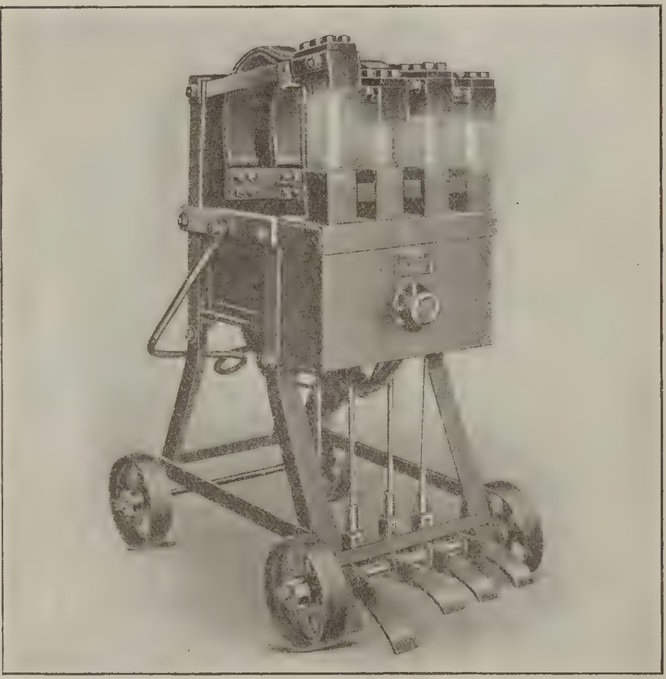
Occasionally electrical men are called upon to paint figures, letters, etc, upon glass which encloses apparatus of various types. In order to make a neat and attractive job it is well to make an outline of the characters desired and then fill in with paint. The difficult part of the task is to obtain a clear, distinct outline. However, the problem is somewhat simplified if a piece of carbon paper is placed next to the glass with the stencil of the required characters on top, then with a smooth, round pointed pencil the stencil may be outlined. Upon removing the carbon paper a clear, clean cut combination of lines forming the figures will appear on the surface of the glass.

NEW DEVICES

Another Rivet Heater

Three electric rivet heaters have appeared on the market during the past year, and the results they have shown apparently indicate they have come to stay. One of these was described in the March, 1920, and another in the May, 1920, issue of the *Railway Electrical Engineer.* The one which has not been mentioned before is manufactured by the Humil Corporation, 101 Park avenue, New York.

Electrically, the Humil rivet heater consists of a specially designed transformer with a single primary winding and one or more secondary windings connected in multiple. The secondary terminals consist of heavy copper blocks between which the rivets to be heated are placed. A control switch in the primary makes it possible to adjust the current or the heat quickly to any desired value within the limits of the machine.



A Four-Head, Type B-4 Humil Electric Rivet Heater

The operation of heating rivets is very simple. The copper blocks which form the secondary terminals are forced apart by a handle or a foot treadle, a rivet is placed endwise between the blocks, and on releasing the handle or treadle the blocks are made to grip the rivet either by their weight or by springs, depending on the type of machine. A stop prevents the blocks from coming in actual contact with each other when there is no rivet between them. A little bump or a slight twist of the rivet insures contact and the rivet starts heating immediately. Owing to its smaller cross-section, the end of the rivet to be upset becomes hotter than the head of the rivet. This, of course, is a desirable feature. As the rivet is not heated in a blast of air, a rivet may be heated and cooled several times without injurious oxidation.

Rivets can be heated in from 3 to 150 seconds, depending upon the size of the rivet, the type of machine used and the number of rivets heated at once.

A machine designed for heating four rivets at once can be used to heat three rivets of larger sizes.

The machines are of rugged construction and the secondaries can be short-circuited indefinitely without injury to the transformers. They can be used in places where it is impossible to use oil furnaces, as they are compact and do not give off objectionable gases. The machines are built to operate on alternating current supply voltages from 110 to 550, but there is no danger to the operator, as the voltage across the secondary terminals is always less than five volts. From five to seven pounds of rivets can be heated with a power consumption of one kilowatt hour.

A New Instantaneous Cell Tester

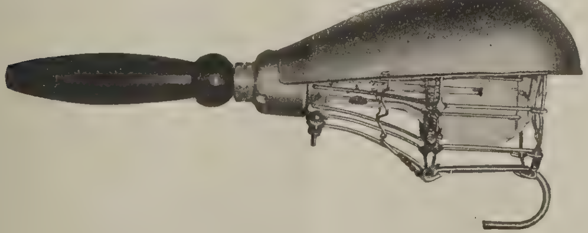
The "Hyrate" cell tester, which is shown in the illustration, is manufactured by the Service Station Supply Company, Detroit, Mich. This device has been designed for making instantaneous tests on individual storage cells of all makes and sizes. Its use is more extensive in service station work, but there are cases in the electrical departments of railroads where its application may prove of service.

This Hyrate cell tester consists of two special steel prods, placed 3 in. apart at the points, with the upper ends assembled in a handle. Between the prods is a special nickel-chromium resistance of 0.01 ohm, and also a voltmeter with 2-0-2 volt scale. This instrument is suspended on rigid supports connected to the steel prods just above the nickel-chromium resistance. The manufacturers state that the special resistance varies somewhat, but imperceptibly, with change in temperature and that it will not oxidize or rust. The voltmeter is of the moving coil type and it is claimed to be accurate and dead beat and of such a size to permit the outfit to be handled conveniently. The tester can be held in one hand and contact can be obtained by pressing the points of the prods into the posts or straps across one cell. Each cell in a battery can in this way be given a high rate discharge, causing the voltage to drop immediately. The discharge rate is approximately 100 times the voltage indicated. That is, if the voltage reads 1.6 during discharge, 160 amperes are being drawn from the battery under test. For instance, if the cells of a battery are being tested for the purpose of determining their condition, the function of the tester is to indicate the voltage of each cell taken consecutively. Should the voltage of a cell drop 1/10 of a volt or more below the others, this cell probably requires repairs or is worn out. Therefore, the tester is claimed to be an instantaneous indicator of the probable condition of individual cells and will aid in picking out the defective ones for further examination and treatment for bringing them back into service.

A Combination of Voltmeter and Leads for Testing Cells Quickly

Portable Light for Use in Shops

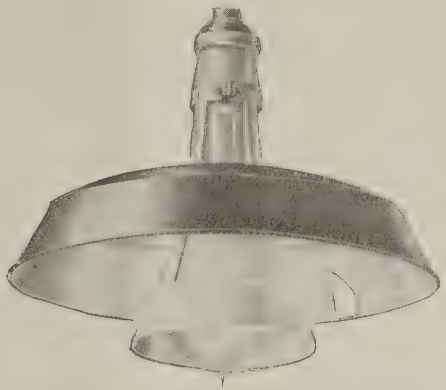
The portable light shown in the illustration has been brought out by the W. N. Matthews & Brothers, Inc., St. Louis, Mo. The fixture consists of a lamp guard made of No. 12 wire, a strong weather-proof aluminum socket and an extra strong reinforced wooden handle. A hook that forms part of the lamp guard permits hanging the light in any location. It is made also with the reflector shade, shown in the illustration.



Protected Extension Lamp

Industrial Lighting Unit

The lighting unit shown in the illustration has been brought out by the Luminous Unit Company division, St. Louis Brass Mfg. Co., St. Louis, Mo. It is designed for mills, factories and shops. The unit consists of a small steel reflector fastened inside of a large reflector. The object of the small reflector is to direct the rays of light so that they are cut off at approximately 40 degrees below the horizontal. Both the inner and the outer surfaces of the small reflector are white enameled. The inside of the large reflector is white enameled, while the outside is finished in brown porcelain enamel. An opening in the top of the large reflector where it joins the socket permits a small amount of light to illuminate the ceiling. The unit is equipped with a clamp holder to fasten it to a medium base porcelain socket.



A Lighting Unit With Two Reflectors for Use in Mills, Factories and Shops

Safety Cartridge Fuse Remover

For removing and replacing cartridge fuses from ½-in. to 1½-in. diameter, The Bush Electric Company of Cleveland has developed the Safety Cartridge Fuse Remover shown in the illustration.

This tool is made of a special insulating material which is extremely tough, but which will not warp or absorb moisture. The construction is somewhat similar to that of a pair of pliers, except that the movement of the handles is multiplied in the gripping jaws, with the result that the tool is simple to operate, only one hand being required. Is convenientiy carried in the tool bag or pocket.

The Cartridge Remover In Use

General News Section

Wilson Welder and Metals Co., Inc., has recently moved from 2 Rector Street, New York City, to 253 36th Street, Brooklyn, N. Y.

The Electric Controller & Mfg. Co., Cleveland, O., has opened a branch office in Boston, Mass., at 49 Federal street. The new office is in charge of M. D. Goodman.

J. H. White has been appointed manager for Cuba for the Westinghouse Electric International Company, with headquarters in the Royal Bank of Canada Building, Havana.

The **General Electric Company,** Schenectady, N. Y., has bought the factory of the Bartlett-Hayward Company, on Columbia avenue, Baltimore, Md., and will use this plant to manufacture electrical devices.

Henry H. Knapp, who for several months past has been acting treasurer of the **U. S. Light & Heat Corporation** of Niagara Falls, N. Y., was elected treasurer at a meeting of the board of directors held May 24, 1920.

Western Electric Company, Inc., New York, N. Y., has established an office at 233 Harris avenue, Providence, R. I., in charge of N. I. Allen. The Rhode Island trade will be given special attention from this headquarters.

Edward A. Everett, manufacturer of railroad and signal appliances, announces the removal of his sales office and factory from 123 Liberty street, New York, to new and larger quarters at 136-138 West avenue, Long Island City, N. Y.

The Frank Adam Electric Co., St. Louis, Mo., announces that it has opened an office and warehouse at 7-9 W. Canal Street, N. S., Pittsburgh, Pa. The new office will be in charge of J. E. Mair, electrical engineer, who is well known in the Pittsburgh district.

The Roller Smith Company, New York City, announces the appointment of **F. R. Ryan** as district manager of its Chicago office located at 739-740 Monadnock Block. **Mr. Frankel,** assistant sales manager of the company, will continue to have his headquarters at the Chicago office.

The Philadelphia Electric Company, during the first weeks of the railroad strike, used up its coal so closely that at one time there was only a single day's supply on hand, and the stock was replenished only by fifteen employees from the company's office going out and manning freight trains to bring in the needed coal.

The Electric Storage Battery Co. announces the removal of its Cleveland office from room 1217-1222 Citizens building to new offices at Chester Avenue and East 24th Street. The new offices will occupy the entire second floor of the "Exide" Battery service station, extensive alterations having been made for the purpose.

Rather a new departure in the method of payment for storage batteries has been inaugurated by the **Edison Storage Battery Company.** Edison batteries for all services can now be bought on the deferred-payment plan, which divides payments over a period of twenty months. It is understood that a trade acceptance is taken with the original payment when the sale is made.

Six passengers and three employees were killed and three employees and 35 or more passengers were injured in a butting collision of two multiple-unit electric trains on the Portland division of the Southern Pacific near Bertha, Ore., on May 9. It is understood that the collision was due to the failure of the eastbound train, No. 124, to wait at Bertha for the westbound train, No. 107.

Chicago Fuse Mfg. Co., Chicago, Ill., announces the acquisition of the Otis Elevator Company's property in that city. The building has been entirely remodeled in accordance with approved ideas of industrial engineering practice and modern equipment has been installed. With the additions that are contemplated, the buildings and equipment will represent an investment of more than a half million dollars. The history of the Chicago Fuse Company shows a steady growth. Starting with the manufacture of "Union" fuses and switch boxes back in 1889, thirty-one years ago, the company has been compelled to enlarge their factory with one addition after another, ending in the purchase of the Otis plant.

Louisville & Nashville Experimenting with Wireless

The Louisville & Nashville is experimenting with wireless telegraph for the purpose of reaching division headquarters located along the Gulf of Mexico from the general offices at Louisville. Certain sections in this area are subject to storms which appear with more or less intensity each year, and which cause considerable damage not only to the telephone and telegraph lines but to the railroad itself. The loss of land communication is a serious detriment to the assembling of material for prompt repairs after such storms and strenuous efforts have been made to maintain telephone and telegraph service on pole lines with varying success.

It is expected that if the wireless is successful, stations will be installed in the storm district around New Orleans and Bay St. Louis, which will communicate direct with the general offices at Louisville. This service will also be of assistance in handling ordinary message business, relieving the congested conditions of the wires. The practicability of radio communication for this purpose has not been thoroughly demonstrated as yet, as the weather effects on wireless constitute an interference which it may not be possible to eliminate. The equipment being used is of the deForest type, long distance service, with which no difficulty has been experienced in reading European and South American stations.

Safety-First on the Chicago & North Western

F. Walters, general manager of the Chicago & North Western, has reissued the circular, promulgated last year, reminding trainmen and enginemen of the importance of special care in approaching highway crossings where automobiles are liable to approach without observing due precautions.

The circular prescribes the "nine-second" whistle signal as indicated by the lines below:

———— ———— —— ——

The first two lines indicate a space of two seconds each; and the other lines, and the spaces between lines, indicate one second each.

Pictures are shown in the circular to emphasize the point that people in automobiles, moving in the same general direction as an approaching train, will sometimes run on to a crossing without raising their side curtains; and to illustrate how a party in a large car will continue in animated conversation, with faces turned away from the railroad. Every engineman is exhorted to take the same precautions that he would if he knew that his own wife or children occupied the endangered automobile.

Material-Handling Committee—Work Enlarged

The Board of Governors of the Material Handling Machinery Manufacturers' Association, 110 West Fortieth street, New York, has appointed 12 special committees. These committees will devote their time to the work of securing better co-operation on the part of the material handling industry and by such efforts to aid in increasing the average production per man with a resultant reduction in the price of commodities. The material handling industry has been divided into six representative divisions as follows: (1) cranes, hoists and winches; (2) gravity and power conveyors; (3) elevators; (4) industrial trucks; (5) bulk handling machinery, and (6) miscellaneous equipment. The 12 committees and their chairmen are as follows:

Membership Committee: E. Logan Hill (Heyl & Patterson, Inc., New York), chairman. Engineering Committee: F. W. Hall (Sprague Electric Works, New York), chairman. Main committee to be made up of the chairman and one additional member of each of the six sub-committees representing the respective six divisions of the industry. Finance Committee: Lucian C. Brown (Elwell-Parker Electric Company, New York), chairman. Meetings Committee: Charles A. Rohr (General Electric Company, New York), chairman. Committee to Co-Operate with Technical Societies: James A. Shepard (Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.), chairman. Committee to Co-Operate with Trade Associations and Industries: J. H. Flynn (Blaw-Knox Company, Pittsburgh, Pa.), chairman. Committee to Co-Operate with Marine Terminal Commissions: C. A. Luster (Clyde Iron Works, Duluth, Minn.), chairman. Committee to Co-Operate with Railroads and Railroad Commissions: Francis L. Stuart (International Conveyor Company, New York), chairman. Committee to Co-Operate with Civic Associations and Governmental Bodies: F. S. Chavannes (Chesapeake Iron Works, Baltimore, Md.), chairman. Special Crane Committee: W. B. Clarke (Manning, Maxwell & Moore, Inc., New York), chairman. Committee on Standardized Containers: Calvin Tomkins (New York), chairman. Publicity Committee, Advertising Council: A. J. Barnes (Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.), chairman.

The committee to co-operate with railroads and railroad commissions consists of Francis L. Stuart, F. B. Fink, I. L. Bretzfelder, B. F. Fitch, F. Logan Hill, F. R. Fishback, Justin Griess, Benjamin Dixon, M. Oliver Crosby and G. A. Mitchell.

The committee on standardized containers consists of Calvin Tomkins, B. F. Fitch, F. W. Hall, F. Stadelman, D. Rushmore, F. L. DuBosque and R. W. Scott.

Material Handling Machinery at the New York Electrical Show

Practically every type of machine used in handling freight shipments at the steamship piers and railroad terminals will be exhibited at the Electrical Exposition to be held at the Grand Central Palace in October.

These exhibits, which are to be a special feature of the show, will be presented and demonstrated under the auspices of the Material Handling Machinery Manufacturers' Association, which has spared no pains or trouble in making this big industrial exhibit comprehensive to the last detail.

In order to have sufficient room to demonstrate properly small trucks, portable cranes, trailers and so forth, the whole third floor will be given over to this purpose.

This will be the first time that the Electrical Show has specialized to any degree in one particular branch of electrical machinery. Economic conditions in the country, though gradually improving, are still far from their pre-war standards, and it is in a measure to help better these conditions through the more general use of electrical industrial machinery that this new policy of the Electrical Show Company has been adopted. Hotel, home, and office appliances are to retain the same prominent positions they have always held at the show and they will be featured in the same manner this year as in previous years. The advent of larger machinery will in no way curtail their prominence.

PERSONALS

Benjamin F. Harmon has been appointed to the newly created position of electrician, first class, on the St. Louis, San Francisco & Texas Railroad with headquarters at Sherman, Texas.

Charles J. Hick has been appointed electrician on the St. Louis-San Francisco, with headquarters at Birmingham, Ala., succeeding **William Rutledge,** resigned, and **W. J. Miles** has been made electrician at the same place, succeeding **B. C. Huffstutter. Hugh W. Brown** and **Ralph Aronson** have been appointed electricians at Oklahoma City, Okla., and **George B. Wallace** electrician at Memphis, Tenn.

B. W. Stemmerich, formerly manager of the equipment section, railway department, Westinghouse Electric & Manufacturing Company, has been placed in charge of the safety car division of the St. Louis office of this company. For 28 years Mr. Stemmerich has been in the employ of the Westinghouse company, as he became associated with it in 1892, or only six years after it was organized. He started as assistant stock order clerk and after several years of clerical and correspondence work he was appointed assistant manager of the railway equipment section of the railway and light department and in 1917 he became manager.

Mr. Stemmerich has been one of the leaders of the organization and development of the electric railway industry and is widely known in the railway field.

A. G. Shaver, consulting signal and electrical engineer, with headquarters in Chicago, has recently been appointed chief engineer of the **Casale Safety Devices Company, Inc.,** New York City. Mr. Shaver was educated at Rose Polytechnic Institute, Terre Haute, Ind., and during his summer vacations worked as a trainmen's caller on the Pennsylvania. After graduating he entered the service of that road as a machinists' helper. In 1898, he left the Pennsylvania to become a signal maintainer and batteryman on the Chicago & Eastern Illinois, resigning from the service of that company on April 1, 1901, to become assistant engineer in charge of the signal department of the Union Pacific, with headquarters at Omaha, Neb. On November 1, of the same year, he was given the title of signal engineer, which position he held until April 3, 1906, when he was appointed signal engineer of the Hall Signal Company, now the Hall Switch & Signal Company, Garwood, N. J. After two years with this company he was appointed signal engineer of the Chicago, Rock Island & Pacific. In May, 1914, he resigned, to become secretary and treasurer of the Hallet Iron Works, Chicago, and in April of the following year he severed his connection with that company and opened an office as consulting signal and electrical engineer at Chicago. Mr. Shaver intends to continue this work in addition to his new duties.

A. G. Shaver

Arnold L. Veith and **Frank Cook** have been made electricians, first class, of the St. Louis-San Francisco Railroad with headquarters at Monett, Mo., and Memphis, Tenn., respectively. These are new positions. **J. H. Gray,** electrician, first class, at the West Shop, Springfield, Mo., has been transferred to the Mill street station in the same capacity, succeeding **T. J. Morgan,** who has taken over the duties of **J. E. Northcutt** at the Mill street station. **William Wade** and **Charles W. Wakefield,** electricians, first class, and **William F. Giltner,** electrician's helper, all located at the South Shop at Springfield, have been transferred to the West Shop at the same place, and **Fred J. Reynolds,** has been transferred from the West Shop to the South Shop succeeding **J. H. Eutsler.** **George M. Graham,** has been appointed electrician, first class, at Kansas, City, Mo., succeeding **C. B. Franklin,** resigned.

John C. Davidson has been appointed engineer of electric traction of the Norfolk & Western, with office at Bluefield, W. Va. Mr. Davidson's early experience in railroad work was obtained in Scotland, where he completed his apprenticeship in the locomotive department of the Great North of Scotland Railway. After completing his apprenticeship he was employed in the drafting room and on material inspection and testing. From 1902 to 1906 he was employed by the British Westinghouse Company as assistant engineer on design of rolling stock and electrical equipment for the Mersey Railway and the Metropolitan Railway electrifications. Mr. Davidson then took up work in the United States and was employed for four years as assistant engineer by the Pennsylvania Tunnel & Terminal Railroad. In this connection he worked on the electrification of the New York tunnels, specializing in the development of locomotive equipment. He entered the employ of Gibbs & Hill, consulting engineers, when the firm was organized. Here he was employed as engineer on projects and designs, appraisals and reports for heavy main line electrification and was engineer in charge of the Norfolk & Western electrification. He resigned from this work to accept his present position.

J. C. Davidson

TRADE PUBLICATIONS

Standard Underground Cable Company, Pittsburgh, Pa.: Bulletin No. 500-T, a forty-page illustrated booklet on "Standard Rubber Insulated Wire," for all purposes.

The Ohio Brass Company, Mansfield, Ohio, is distributing a two-color folder illustrating and describing the O-B Arc Welding Machine and Rail bonds made with it.

Appleton Electric Company, Chicago, Ill., have just issued its Bulletin No. 13 giving a complete listing of "Pagrip" Metal Molding and Fittings. Copies will be sent upon request.

The Bush Electric Co., Cleveland, Ohio, is distributing a small envelope folder illustrating and describing the "Bush Remover," an insulated tool for use in removing and inserting cartridge fuses.

Tructractor.—The Clark Tructractor Company, Chicago, has issued a pamphlet showing photographs and specifications of all models of the Clark Tructractor, with illustrations showing it at work in various industrial plants.

Railway
Electrical Engineer

Volume 11 July, 1920 Number 7

NOTICE TO SUBSCRIBERS

Occasionally we learn from some subscriber to the *Railway Electrical Engineer* that he has forwarded a money order in payment for his subscription but has failed to receive the paper. Sometimes the complaint comes direct to us from the subscriber, which is the way it should come. Very often in such cases, however, the complaint is made, not to us, but to others, and reaches us by roundabout ways, or probably not at all. A little consideration immediately shows the injustice to the publishers in this method of complaining, for a wrong impression may be very easily created. We want you to receive your copy of the *Railway Electrical Engineer*. If you do not get it, do not tell others about it—tell us, and you can be very certain that the matter will be taken care of with all possible despatch.

TRANSPORTATION IN 1930

Much has been said, and more will be said, about the advantages of moving trains by electric power. Practically every dissertation on this subject brings out the fact that electrification projects become tremendously expensive when they finally materialize. That the first cost of electrifying any road is high no one will contend, but is it not possible that too much emphasis is laid upon this first cost ? The traffic of this country will certainly not grow less in the years to come, but, on the contrary, will increase enormously. Present day motive power facilities can never hope to cope with the traffic conditions ten years hence. By 1930 the movement of freight on many lines will have grown to such an extent that continued operation by steam power will be quite impossible except by increasing the number of tracks. Is it going to be cheaper to build these tracks ten years from now and to maintain them than it would be to spend the same amount of money for electrification today and enjoy the advantages of superior operation ? This is the real problem for the executives to decide. Some will see the light and be guided; others will be perversely blind. In the end the latter will be either forced to follow the example of the leaders or be content to become second raters in every sense of the word.

It will be quite impossible to move the traffic of 1930 without an enormous increase in electrified roads. It has been clearly shown that one electric locomotive can exert more drawbar pull than two of the largest steam locomotives. There is practically no limit to the power that the electric locomotives can be designed to exert, but the power of the steam locomotive has about reached its maximum without becoming too cumbersome. Long trains will be the common unit in 1930. It has even been prophesied that trains as heavy as 14,000 tons will be moved. What other than the electric locomotive can do such hauling?

THE 1920 SEMI-ANNUAL CONVENTION

The semi-annual convention of the Association of Railway Electrical Engineers, held last month in Atlantic City, was well attended by electrical men from all parts of the country. While the entire program which had been outlined was not carried out, the reports which were presented, and which are published elsewhere in this issue of the *Railway Electrical Engineer,* were both interesting and instructive, particularly the report of the Committee on Train Lighting Equipment and Practices.

In discussing these reports, however, there seemed to be a tendency to devote too much time to the consideration of trivialities. While it is perfectly true that the open discussion following the presentation of any report is for the primary purpose of bringing out all of the important aspects of the subject, it is equally true that much valuable time can easily be wasted in discussing matters which are in reality only trifles. The development of electrical matters on the railroads is taking place so fast and there are so many really big problems for electrical men to cope with that a determined effort should be made to confine convention discussion to a consideration of the important features of the reports.

It will be recalled that the question of the association becoming a part of the American Railroad Association was introduced last October at Chicago. While it was not discussed at the semi-annual meeting, Mr. Billau spoke briefly about some of the more important features of such an amalgamation. Apparently a majority of the members are in favor of such a union; in fact, it appears to be a matter of only a short time before such a union will be effected. That advantages will be derived from the combination cannot be doubted. Heretofore, the electrical men have sought recognition in vain through the functions of the Association of Railway Electrical Engineers. This has been clearly evidenced by the fact that the American Railroad Association has had duplicate committees on the important electrical subjects. Not only is such duplication inefficient, but it shows clearly where the electrical men stand regarding questions upon which their judgment and decisions should be respected. The combination is certain to result in definite raising of the standards of the electrical men; more men of engineering calibre will be attracted and the meetings of the electrical unit of the American Railroad Association will be looked upon by railroad executives as a very potent factor in the solution of big railroad electrical problems of the future.

ESSENTIALS FOR SUCCESSFUL ARC WELDING

The railroads present a greater field for electric arc welding than any other industry. Nowhere else can so many iron and steel parts be found. There are few places aside from the railroads where these parts are subjected to such severe stresses. Prior to the advent of electric arc welding thousands of dollars' worth of worn out and broken parts had to be scrapped every year. To a very large extent this practice is rapidly becoming obsolete, for more repairs, which a few years ago were not considered possible, are being constantly made by the electric welding process; nevertheless, it cannot be said that electric arc welding has been developed to its greatest possibilities. The future which lies before arc welding does not depend so much for its success upon radical changes in the methods of performing the work as it does in a better understanding of the factors which are so essential to the successful application of the art.

One of the most essential factors in the accomplishment of successful welding is the use of proper materials. Welding electrodes of the proper chemical composition are absolutely necessary. While it is true that a semblance of a weld may be made with inferior electrodes, it is exactly that—a semblance of a weld—and it requires but a brief period of service before the part which appears to be welded breaks down. To those who have made a study of welding, such a result is not at all surprising, but those who have not made such a study are too quick to condemn the art on the basis of such a failure.

Another factor of vital importance in successful welding is the employment of a careful and trained operator. There is perhaps no greater fallacy in connection with welding work than that of thinking that any man who can draw an arc is a welder. To the unskilled observer such an individual apparently performs his work in the same manner as the trained operator, but in reality there is a world of difference between the performance of a skilled and unskilled man in the use of the electric arc. Until the fact becomes more thoroughly recognized that a long and rigorous course is required for training welding operators, the art of welding will be hampered in its development. In view of the important position which electric arc welding is destined to occupy on the railroads it would not seem possible that too much attention could be given to the training of operators. It is obvious that important welding jobs should be given to only trained men, and in order to establish a standard as to who shall be considered as a trained man it might simplify matters considerably by requiring welding operators to possess a license, such license having been secured upon the successful completion of a course in a recognized school of welding.

A third essential for successful work which is equally as important as the other two, is the proper supervision of the welders. While a welding operator may be able to make the best kind of a weld, there are other factors, such as the advisability of making a weld in a certain casting, which might easily fall without the scope of the welder's knowledge, regardless of the fact that he might be an expert. It is for this and similar reasons that supervision of arc welding work is essential if successful welding is to be secured.

Once the importance of these three essentials, best welding materials, trained operators, and proper supervision, have become thoroughly recognized, general practice electric arc welding will be well on the way to its proper place in the railroad industry.

NEW BOOKS

Proceedings, American Electric Railway Association, 1917, 1918, 1919. 5 volumes, 6 in. by 9 in., illustrated. Published by the American Electric Railway Association, 8 West 40th street, New York, N. Y.

These five volumes contain the proceedings of the annual conventions of the A. E. R. A. and its subordinate sections held at Young's Million Dollar Pier, Atlantic City, N. J., October 6, 7, 8 and 9, 1919. The individual volumes contain proceedings as follows: American Electric Railway Association, thirty-eighth annual convention, 334 pages; Engineering Association, seventeenth annual convention, 416 pages; Transportation and Traffic Association, twelfth annual convention, 238 pages; Claims Association, sixteenth annual convention, 140 pages; Accountants Association, twenty-third annual convention, 145 pages. No annual conventions of the A. E. R. A. were held during the years 1917 and 1918.

Proceedings, Association of Railway Electrical Engineers, 1919, 6 in. by 9 in., 235 pages of text, illustrated. Published by the Association of Railway Electrical Engineers, Chicago, Ill.

This book contains the proceedings of the semi-annual convention of the A. R. E. E. held at the Hotel Dennis, Atlantic City, N. J., June 23, 1919, and the proceedings of the eleventh annual convention held at the Hotel Morrison, Chicago, Ill., October 28 to 31, 1919. The subjects dealt with by the association are the electrical problems of the steam railroads and consist of the following: electric headlights, electric headlight handbook, illumination, electric arc welding, train lighting equipment and practice, electric headlight forms, electrification, railway stationary power plants, and the question of amalgamating the A. R. E. E. with the American Railroad Association as a division of Section III—Mechanical.

Service at Cost Plans, by Harlow C. Clark editor of the "A. E. R. A." 6 in. by 9 in. Bound in cloth. 315 pages. Published by the American Electrical Railroad Association, 8 West Fortieth Street, New York.

This book is explained in its sub-title to be an identical analysis of statutes, ordinances, agreements, and commission orders in effect or proposed concerning service at cost plans, together with a discussion of the essentials of local transportation franchises. It is, properly speaking, divided into three parts: The first part discusses the essentials of a franchise and considers such elements as the effect of definite termination, the investors' requirements, the provision of revenue, the importance to be given to depreciation, attrition, etc. The second part is a detailed analysis of the service of cost plans in effect in Cleveland, Boston, Memphis, Youngstown, Cincinnati and other cities. This analysis is compiled from material that has appeared in issues of Aera, and is carried out not under the heading of the various plans but rather in the form of a topical analysis of the various factors that are concerned in the plans. The third section is a similar analysis of plans which have been proposed but which have not been put into effect.

Semi-Annual Convention of the A. R. E. E.

Committees on Illumination, Electric Headlights and Train Lighting Equipment Present Progress Reports

THE Association of Railway Electrical Engineers held its semi-annual convention at the Hotel Dennis, Atlantic City, N. J., on Monday, June 14. The meeting was called to order at 10:15 a. m., by the president, L. S. Billau, of the Baltimore & Ohio.

During the course of the brief introductory remarks by Mr. Billau the subject of the Association of Railway Electrical Engineers becoming a part of the American Railroad Association was again brought up. It will be recalled that this question was first introduced before the convention of the association at Chicago last fall. At that time the railroads were under government operation and hence this question presents slightly different aspects today from what it did then. There are decided advantages, however, to be gained from such consolidation, and there is every reason to believe that the Association of Railway Electrical Engineers will unite with the larger organization when certain changes have been made in the constitution of the latter.

Mr. Billau explained that in the event of the A. R. E. E. becoming a part of the A. R. A. the election of officers would be carried on by letter ballot, and that the choice of candidates would lie in the hands of a nominating committee. Furthermore, he stated that such a committee would also be elected by letter ballot. Another change involved in re-arranging the present methods of the A. R. E. E. to conform to the practices of the A. R. A. would be the appointing of a Committee on Subjects from the members of the Executive Committee, this Committee on Subjects to present a list of subjects to be discussed for action the following year. Other minor changes were mentioned, among which was a possible change in the dates for the annual and semi-annual conventions.

Although quite a number of reports had been scheduled for the meeting, only three of them appeared in printed form. These were the report of the Committee on Illumination, the report of the Committee on Train Lighting and Practice, and the report of the Committee on Electric Headlights. In order to economize in time none of these reports were read, the association members having been furnished with printed copies sometime previous to the convention. The entire time was therefore available for discussion. The longest report considered was that of the Committee on Train Lighting Equipment and Practice. The report is given here in full.

Report of Committee on Train Lighting Equipment and Practice

Your committee was instructed to investigate and report on the following subjects:

Preparation of standard specification for axle generators.

Desirability of increasing the recommended minimum inside height of battery boxes.

The corresponding committee of Section III, Mechanical, of the American Railroad Association, is also investigating the subject of axle generator suspension, and arrangements were, therefore, made to hold joint meetings of the two committees.

Representatives of the axle generator manufacturers were invited to attend the meetings of the committee and considerable correspondence was conducted with them and also with the manufacturers of ball bearings.

Before presenting the result of the work of the committee in the shape of a Specification, it seems desirable to discuss, in more or less detail, the various features that were considered. This discussion will serve to explain why certain items, which form part of a complete specification were omitted; and why items that were included were finally decided upon.

Generator Frame Material

Generator frames may be made of rolled or cast steel or of cast iron. Cast iron is lower in cost per pound than steel, but has a lower magnetic permeability, therefore requiring a greater weight to obtain the same electrical effect. From a service standpoint each material is acceptable and the decision which to use is really based on economic considerations; modified by the space requirements that must be observed. Where space is a factor, the frame should be of cast or rolled steel. Where space is not a factor, cast iron may be used.

Lugs on Generator Frame for Suspension, Belt Tension and Safety Device, Location and Size

Various attempts have been made to standardize these lugs, but all have failed, due principally to the variety of suspensions and belt-tension devices in use, caused by the differences in car body and truck design. Your committee, therefore, felt that it was useless to attempt to standardize this feature. However, the necessity of replacing axle generator frames, due to accident or wear, is a rare occurrence and therefore the standardizing of these lugs is comparatively unimportant, insofar as interchange between railroads is concerned.

Generators should be overhauled periodically and this work is generally done by the owning road. Such overhauling can best be done by removing the generator from the car and taking it into the shop. In order to avoid holding the car out of service it is desirable to be able to replace the generator removed with a generator that is known to be in good order. It is therefore an advantage to any road to have the location and size of the generator frame lugs identical on all axle generators of their ownership so that this exchange of generators can readily be made.

If a railroad will analyze the conditions as found on their own cars, your committee believes it possible, in most cases, to design the suspension and belt tension so as to permit the location and size of the necessary lugs on the axle generator being fixed, and all axle generator manufacturers can usually furnish generators having the lugs in the location desired. This procedure has already been followed by some roads with very good success.

With regard to safety lugs, the necessity of these, especially on body hung generators, is open to question. The Mechanical Engineers of many roads prefer to omit them and make the suspension lugs of such design that they are of more than sufficient strength for the duty required. Wear of the holes in the suspension lugs will result in improper alignment of the generator, causing a loss of belts and in time will necessitate scrapping the generator frame from considerations of safety. To prevent this wear it is good practice to bush the holes in the suspension lugs with a bushing properly secured in the lug.

While in no way related to the question of axle generator specifications, we desire at this time to call attention to a matter that should receive particular attention when considering the type of suspension. The question is that of clearance of the belt and belt-fasteners from any portion of the truck and car body, as the amount of clearance is a very important factor in determining the mileage obtained from the belt. Especial effort should be made to make this clearance, initially, as great as possible, so as to take care of wheel wear, brake rigging wear, spring deflection, etc. When proper allowance has been made for the effect of all factors, which tend to alter the amount of the belt clearance and reduce it to a minimum, your committee feels that under such conditions of minimum belt clearance, the clearance from any part of the belt or belt-fastener to any part of the truck or car body should be at least ½ in. (See Proceedings A. R. E. E., Page 159, Vol. 9, 1916.) The best belt conditions are obtained when both brake beam and truck end-sill come between the two runs of belt.

Armature Shafts Material

Armature shafts were formerly made of mild steel and trouble with these shafts breaking or bending at the pulley end was encountered. This trouble was probably due in some cases to the strain caused by excessive belt tension, in others to the shock of coupling or to torsion developed when the bearings seized. The use of ball bearings has practically eliminated the latter cause and at the same time has necessitated, in order to mount properly the bearing and permit its removal and reapplication, the use of a better grade of steel. It, therefore, seems desirable to specify the characteristics that a steel suitable for this purpose should possess.

Assembly of Armature

For years the armatures of axle generators were built with the laminations and end plates keyed directly to the armature shaft, a construction that necessitated scrapping the armature when the shaft was damaged. Modern armatures of all types of electrical machines have the laminations and end plates and also the commutator assembled on a quill and the quill is then keyed to the shaft. This construction permits the removal and replacement of the shaft.

Bearings

The sleeve bearings that were originally used on axle generators were a most prolific source of trouble, due to wearing, running hot and seizing. Also the bearings were not interchangeable, almost every make and type of generator requiring a different bearing. These conditions required that the bearings be frequently and carefully inspected, as excessive wear would permit the armature to drop and strike on the pole face, damaging both field and armatures. In order to guard against this condition and postpone the day on which it would be necessary to renew the bearings on account of legitimate wear, it was customary to design the generator with an air gap having a liberal mechanical clearance, which of course tended to increase the size of the generator and also the cost. Ball bearings seemed to offer a remedy for this trouble, inasmuch as they had been standardized by the manufacturers in a series of definite sizes, so that ball bearings of any given size, no matter by whom manufactured, were interchangeable and due to the construction of the bearing the clearance of the air gap could be reduced materially without danger to the armature striking on the pole faces.

The movement to standardize ball bearings was started at the time the use of ball bearings was first begun. After consultations with the ball bearing and axle generator manufacturers a series of sizes was selected and reported by the committee. (See Proceedings A. R. E. E., Page 87, Vol. 10, 1918.)

Your committee now recommends that two additional sizes be added, as shown in the table on sizes of ball bearings, as given in the specification.

It is essential to obtain good service that ball bearings be not overloaded and also the manner in which the bearings are mounted is of great importance in determining the service to be obtained. Thus one bearing must approximately be fixed in position, while the other must have a longitudinal movement so that it can accommodate itself to the change in length of the armature shaft, as these changes occur with varying temperatures. The load on a bearing is either radial, thrust, or a combination of the two. From the nature of the design the greater part of the radial load must be borne by the pulley bearing, and it is therefore customary, in order to equalize the load, to make the commutator end-bearing sustain the thrust.

It is also essential that a proper fit of the shaft in the bearing and of the bearing in the housing be obtained. If the shaft is too small, or the housing either too large or too small, the bearing will not function as a bearing. If the shaft is too large the inner race of the bearing will probably crack when the attempt is made to mount the bearing on the shaft.

In the past such terms as "sucking fit," "press fit," and "light drive fit," were used to describe the various kinds of fit desired; but these terms were not accurate, and it seems best that certain dimensions with allowable tolerances be fixed. The question was therefore taken up with the ball bearing manufacturers and information obtained relative to the above, together with corresponding data concerning the bearings themselves.

Grease Retainers

When sleeve bearings were used, oil was the lubricant employed, and this oil would travel along the shaft and into frame, where it would become mixed with carbon dust and cause grounds; or become deposited on the commutator, causing the generator to fail to generate. With ball bearings, which in this service, ordinarily use grease as a lubricant, the same trouble is sometimes experienced during very warm weather, if an excessive amount of grease be placed in the bearing and some provision be not made to retain it. This trouble can be prevented if grooves be machined in the bore of the end housings and felt washers fitting the shaft snugly be applied to the inner side of the commutator end housing and to both sides of the pulley end housing.

Pulleys, Pulley Nuts and Keys

In past years your committee has made recommendations relative to armature pulleys, pulley nuts and keys. (See Proceedings A. R. E. E., Page 85, Vol. 10, 1918.)

The idea on which these recommendations were based was to standardize fully the armature pulley so that renewals could be promptly made to foreign cars, and three sizes, i. e., 5½ in., 8 in. and 11 in. diameter, were selected. It now appears advisable, in view of the advent of the "controlled speed" axle generator and what will later be said on the subject of "capacity" and "minimum full load speed," to increase the number of pulleys as determined by the diameter, while retaining the other dimensions, such as bore, taper, etc., which will enable one to renew a broken pulley even though the pulley applied be not of proper diameter to obtain the minimum full load train speed for which the generator was intended.

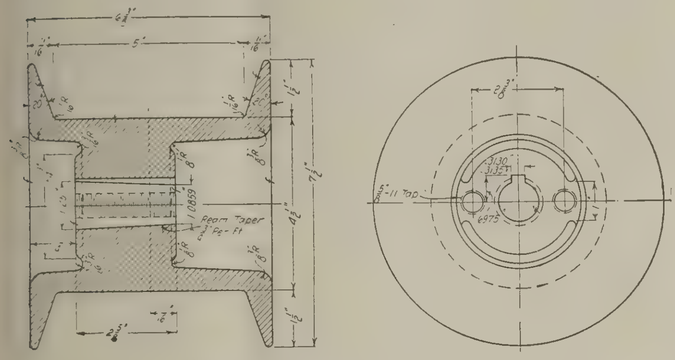


Fig. 1—A 4½ in. Pulley for Controlled Speed Generator

Armature pulleys have been made of pressed steel, cast steel, malleable iron, cast iron and various composite structures. General experience indicates that of these various materials, cast iron, everything considered, is the most suitable for the work, and that much of the trouble that has been experienced with cast iron pulleys has been due to the design.

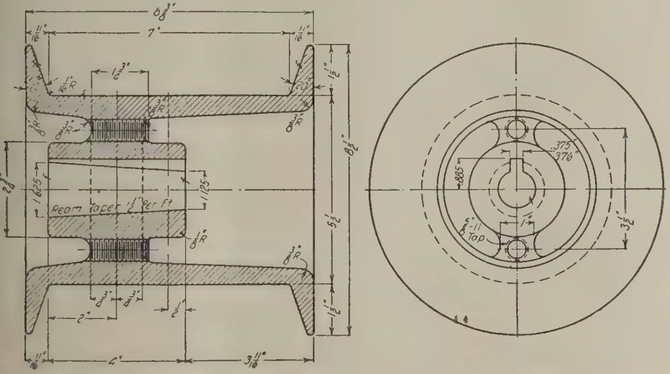


Fig. 2—A 5½ in. Pulley for Controlled Speed Generator

Your committee has therefore prepared design for cast iron pulleys in the following sizes:

Controlled speed generators. Diameter of pulley—Inches	Free speed generators. Diameter of pulley—Inches
4½	5½
5½	6½
	8
	10

The designs being such that it is hoped that the trouble, i. e., broken flanges, will be at least partially overcome. These designs are shown on Figs. 1 and 2 for controlled speed generators and Figs. 3 to 6 inclusive, for the free speed generators.

Pulleys of these designs for free speed type of generators are interchangeable for all makes and sizes of generators of the general type having the pulley fit shown in Fig. 1, Page 85, Vol. 10, 1918, for axle generator having ball bearings.

The size of the armature pulley that should be used in any given case will depend upon the maximum load, the minimum full load speed desired, the pulley ratio, the maximum size pulley permissible and the belt clearances.

Field Coils

When field coils are constructed so that there are no means, other than the outer layers of tape, for holding the several turns fixed in their relation to one another, movement of the several turns results, due to the vibration occurring from service conditions.

As the cotton insulation that is generally used will in time char, due to the heat generated by the operation of the generator, this movement will flake off the charred insulation and the turns will be short-circuited, or in other words, the coil will be burned out. The vibration will in time similarly affect a similar coil insulated with Class "B" insulation. It is therefore important that the several turns and layers be so held that no relative movement can occur. This can be accomplished by impregnating the coils with an insulating compound which binds the several layers and turns into one solid mass so that no relative movement can result. Therefore, your committee is of the opinion that field coils should be impregnated to conform with established practices of electrical manufacturers or thoroughly saturated by dipping process with insulating material and then baked.

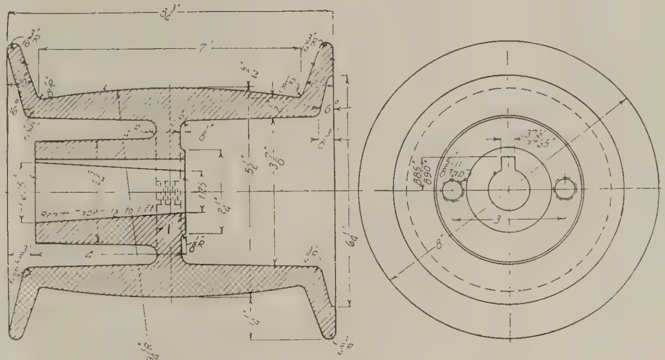


Fig. 3—A 5½ in. Pulley for Free Speed Generator

Air Gap

The smaller the air gap, that is, the distance radially between the iron of the armature and the pole face, the less the reluctance of the magnetic circuit, and therefore the less the number of ampere turns which are required to energize the field. Decreasing the air gap therefore tends to reduce the size of the generators and also its first cost. The use of ball bearings permits the use of a small air gap, as little provision for wear is necessary. Experience has shown that

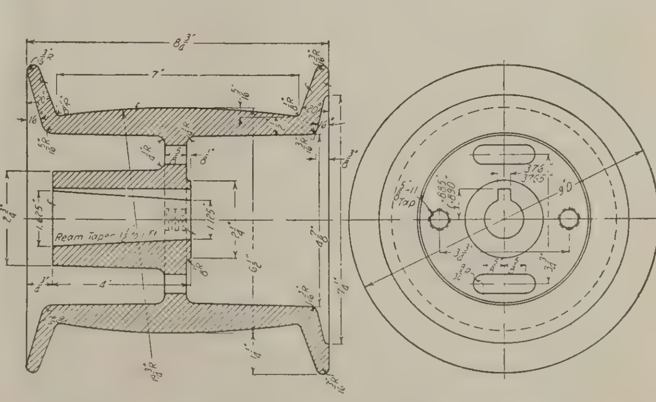


Fig. 4—A 6½ in. Pulley for Free Speed Generator.

when using ball bearings, the mechanical clearance in the air gap will be sufficient, if it is possible to pass in a direction parallel to the shaft, at all points between the armature and the pole faces, an oval feeler ½ in. wide and 0.05 in. thick.

Regulator—Location of Holes for Supporting Bolts

The two Z-bars or other shapes by which the generator and lamp regultor panels are supported are, ordinarily, most conveniently placed in the regular cabinet in a vertical position. Therefore, if the horizontal distance between the centers of the holes in the panels through which the supporting bolts pass is standardized, one location of these regulator supports may be employed which will tend to simplify the car construction. It is, of course, desirable that the vertical centers of the same holes be also standardized, but not so important as it is for the horizontal holes. Your committee investigated this matter and found the horizontal center of these holes varied from 13 to 14¾ in. while the vertical centers varied from eight to 31 in.

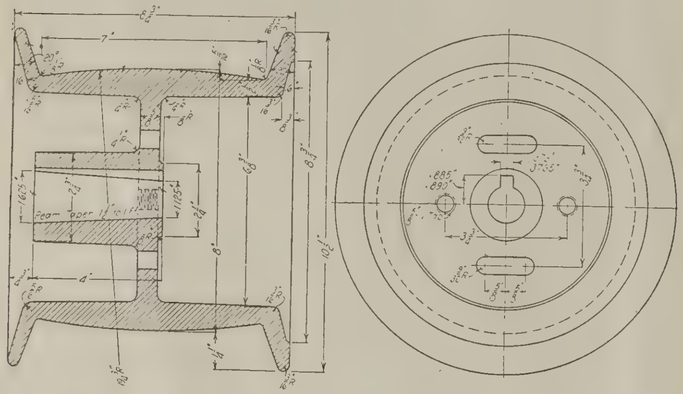


Fig. 5—An 8 in. Pulley for Free Speed Generator.

By agreement with the axle generator manufacturers, the width of all panels, both generator and lamp regulator panels, has been made 16 in. and the horizontal distance between center of holes which are 7-16 in. in diameter, has been made 14 in., they being placed 1 in. from each side and also 1 in. from each end of the panel.

In order to prevent the supporting frame work short-circuiting the wiring on the rear of the panels, it is frequently necessary to have clearance at this point.

The corner bracket used for this purpose to be interchangeable and to make all panels interchangeable should be designed so that the holes for the supporting bolts shall be the same size as the hole in the panel, i.e., 7-16 in., and when mounted on the panel should have the same horizontal distance between centers, i.e., 14 in.

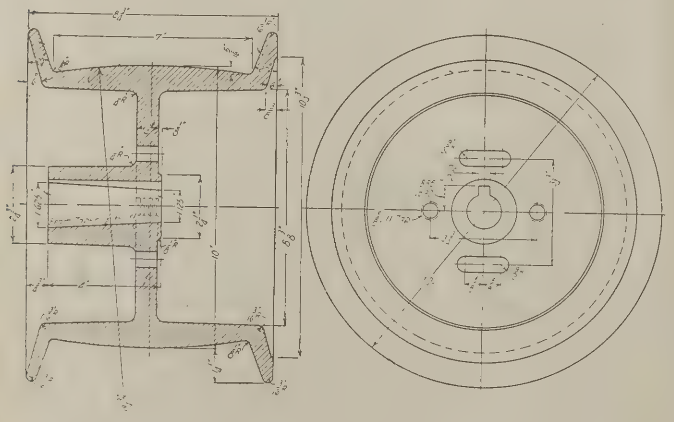


Fig. 6—A 10 in. Pulley for Free Speed Generator

Cutting in Speed

The r.p.m. of the armature shaft or the speed of the train in miles per hour, at which the automatic switch closes, thus connecting the battery and load circuits to the generator, is known as the "cutting in speed." This speed is a function of the design of the generator. Roughly, this speed will be about 75 per cent of the minimum full load speed.

Maximum Speed

The maximum speed is that speed at which the generator may be operated without trouble, either of an electrical or mechanical nature, developing. The 36 in. diameter car wheel is generally used under passenger equipment cars and this wheel, when worn to the limit, is 33 in. in diameter. The maximum train speed permitted by the rules of most railroads is about 75 miles per hour. The rotative speed of a 33 in. wheel on a car traveling at the rate of 75 miles per hour is equal to the rotative speed of a 36 in. wheel on a car traveling at the rate of 81.8 miles per hour. Therefore, the armature must be built to be mechanically safe when the car, with the pulley ratio as intended and using a 33 in. wheel, is traveling at the rate of 75 miles per hour.

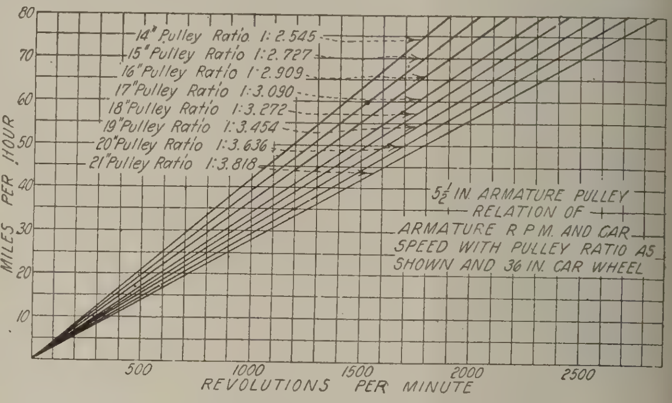


Fig. 7—Curves Showing Relation of Armature R.P.M. and Car Speed for a 5½ in. Armature Pulley

Owing to the manner in which free speed axle generators are ordinarily controlled, an increase in the armature speed necessitates a decrease in the field current. At high speeds, therefore, a very weak field is used, with resultant liability of vicious sparking at the brushes, due to the plane of commutation shifting on account of the change in the value of the ampere turns in the fields with respect to the ampere turns in the armature.

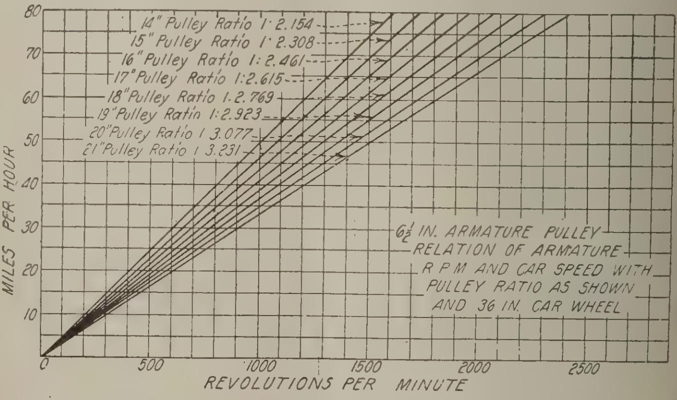


Fig. 8—Relation of Armature R.P.M. to Car Speed for a 6½ in. Armature Pulley

However, excessive sparking may continue for some time and damage the generator, only to the extent of necessitating the turning of the commutator, but failure of the armature mechanically, will result in the destruction of both fields and armature.

Minimum Full Load Speed

The minimum r.p.m. of the armature, or the minimum miles per hour of car travel at which the generator will carry full rated load, is known as the "minimum full load speed."

It will be noted that the relative values of the two ways of expressing this speed will vary with the pulley ratio and size of wheel.

This relation is shown on Figs. 7 to 10, inclusive.

The "minimum full load speed," expressed as r.p.m. of the armature, is a factor of prime importance in the design of the axle generator; a lower r.p.m. generally necessitating a larger generator. Until quite recent years, axle generators were purchased principally for use on cars operated in through service on the main line of railroads, where ordinarily the distance, and therefore the time interval between stops, was considerable, while the average rate of speed was comparatively high. Under these circumstances a minimum full load speed of approximately 25 miles per hour was low enough to give satisfactory operation.

However, a point has lately been reached in equipping passenger cars with electric light that makes it necessary to consider the conditions which obtain when the cars to be lighted are operated in branch line or local service.

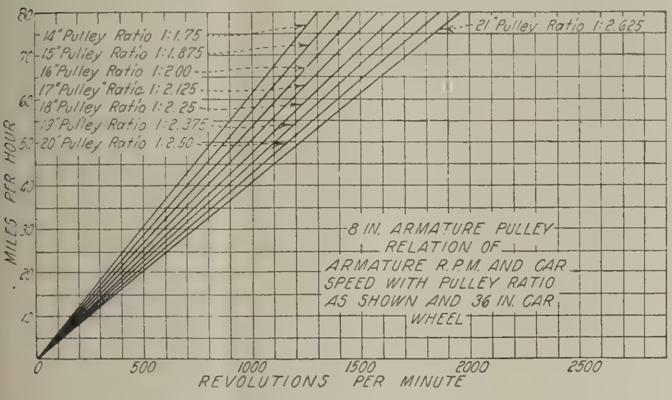


Fig. 9—Relation of Armature R.P.M. to Car Speed for an 8 in. Armature Pulley

The operating conditions that are generally characteristic of branch line and local service are:

(a). A less distance between stops than is generally encountered on main lines, and therefore a less time interval between stops.

(b). A lower schedule speed, both average and maximum.

(c). A less total distance to traverse in a day.

Therefore, the actual time that the axle generator is in operation per day is generally less in branch line and local service than it is in main line service, and the percentage of the total elapsed time of the run that the train speed is above a given figure is also less.

It is therefore apparent, that an axle generator which will maintain the lighting of a car in main line service, may give entirely unsatisfactory results when the car is operated in branch line or local service; but that a generator that will maintain the lighting in branch line and local service will also maintain the lighting in main line service. In other words, the generator with the low minimum full load speed will maintain the lighting in both classes of service.

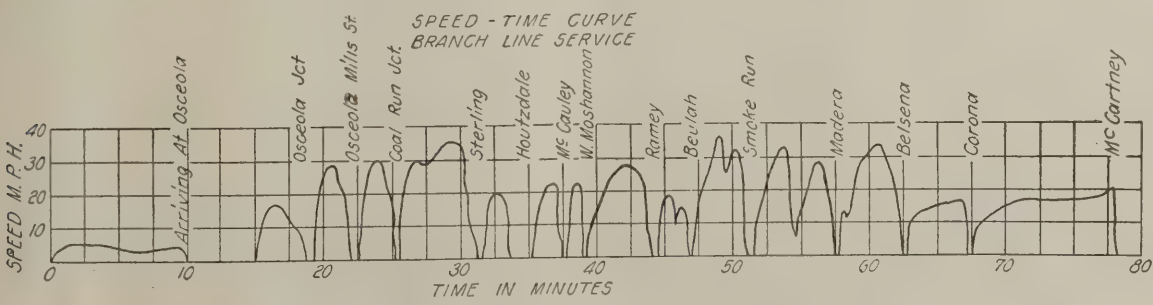


Fig. 11—Typical Speed Time Curves of Branch Line Operation

As operating conditions may cause cars assigned to branch line or local service to be shifted to main line service and vice versa, it would seem desirable, from an operating point of view, to have all cars equipped with generators which will permit the car to be used wherever it may seem desirable.

If generators with a given minimum full load speed will not satisfactorily maintain the lighting of the car, there are only two remedies in so far as the axle generator is concerned:

(a). Decrease the minimum full load speed so as to have the generator in action a greater proportion of the time.

(b). Increase the net ampere capacity of the generator.

Both courses result in an increase in the total ampere hour output of the generator and both will entail a generator of larger physical dimensions.

It is a comparatively simple matter to take a series of speed time curves and from an inspection of them determine a proper minimum full load speed, and then calculate the net ampere capacity required of the generator. It is a much more difficult problem to assume a new ampere capacity and determine the maximum possible value of the minimum full load speed.

Typical speed time curves of branch line operation are shown on Fig. 11.

The question is further discussed under the caption, "Net ampere capacity for axle generators."

Designation of Axle Generator Capacity

Heretofore it has been customary to refer to axle generators as having a certain kilowatt capacity. In view of the association in 1919 having adopted as Recommended Practice that the rating of axle generators shall be expressed in amperes, it appears preferable to refer to them hereafter as having a certain "net current capacity."

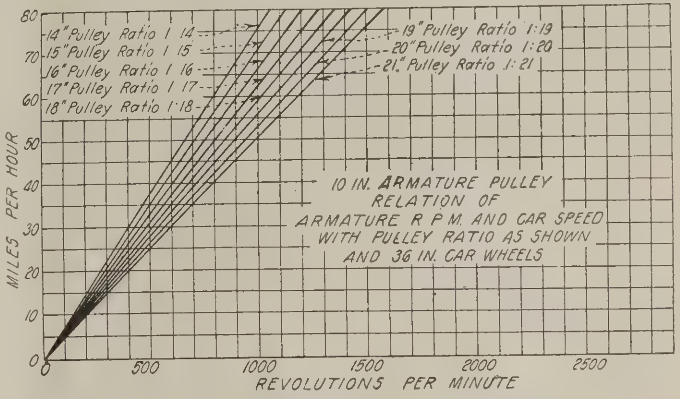


Fig. 10—Relation of Armature R.P.M. to Car Speed for a 10 in. Armature Pulley

Net Current Capacity of Axle Generators

In determining the minimum net current capacity of an axle generator that will be required to maintain successfully the electric service on a certain run, consideration must be given to several conditions.

The two factors which determine the minimum generator capacity are the amperes on battery discharge and the battery capacity, and these vary with:

(a). The size of the car, that is the number and voltage of the lamps, fans, etc., installed on the car.

(b). The amperes required to operate the lamps, fans, etc., when the maximum number in service at any one time is turned on.

(c). The magnitude and duration of the various discharges of the battery and the time at which each occurs with respect to the full cycle of operation of the car.

(d). The speed time curve of the car for its full cycle of operation, taking into consideration the question of the relation of the time at which current will be required with respect to this speed time curve.

(e). Having decided upon the voltage of the battery, a study of conditions (a), (b) and (c) will determine the ampere hour capacity of the battery to be used; and the capacity determines the normal rate of charge and discharge of the battery.

(f). Conditions (c), (d) and (e) must then be studied to determine the net ampere capacity of the axle generator.

To do this a minimum full load speed must first be assumed. Then the generator while running at this or higher speeds must furnish all current required by the lamps, fans, etc., and in addition it must replace in the battery the ampere hours consumed when the speed is less than the assumed minimum speed plus additional ampere hours sufficient to compensate for the ampere hour efficiency or inherent losses of the battery.

Of course, the higher the minimum full load speed is assumed, the greater the net current capacity of the generator must be; as in the same cycle of operation of the car, it is in action a lesser time, while the ampere hour requirements may be and generally are increased.

From the above it will be seen that to cover the entire field, i.e., all classes of cars, kinds of service and character of runs, the calculated minimum net ampere capacity would probably vary with each possible combination.

It should also be noted that, while a higher minimum full load speed in miles per hour entails a large output in ampere hours, and ordinarily would require a generator of larger capacity, this is not necessarily so, and in fact the reverse may be the case.

The reason for this is that as yet the question of the minimum armature r.p.m. at which the generator will carry the desired net amperes has not been considered.

Minimum Armature Speed

The minimum armature speed depends upon:

(a). The minimum train speed at which the generator must carry the desired net amperes.

(b). The diameter of the car wheel.

(c). The relative diameter of the axle and armature pulley, i.e., the ratio of reduction.

When considering the minimum armature r.p.m. at which the net ampere capacity is to be generated and the ratio of reduction to be used, the question of the maximum armature r.p.m. must not be lost sight of, as otherwise, at high train speeds, the r.p.m. of the armature may be so great as to be dangerous.

Consideration of the above indicates that for any given case a great number of solutions is possible, and that, when all cases are considered the number of possible solutions of the minimum net ampere capacity is infinite.

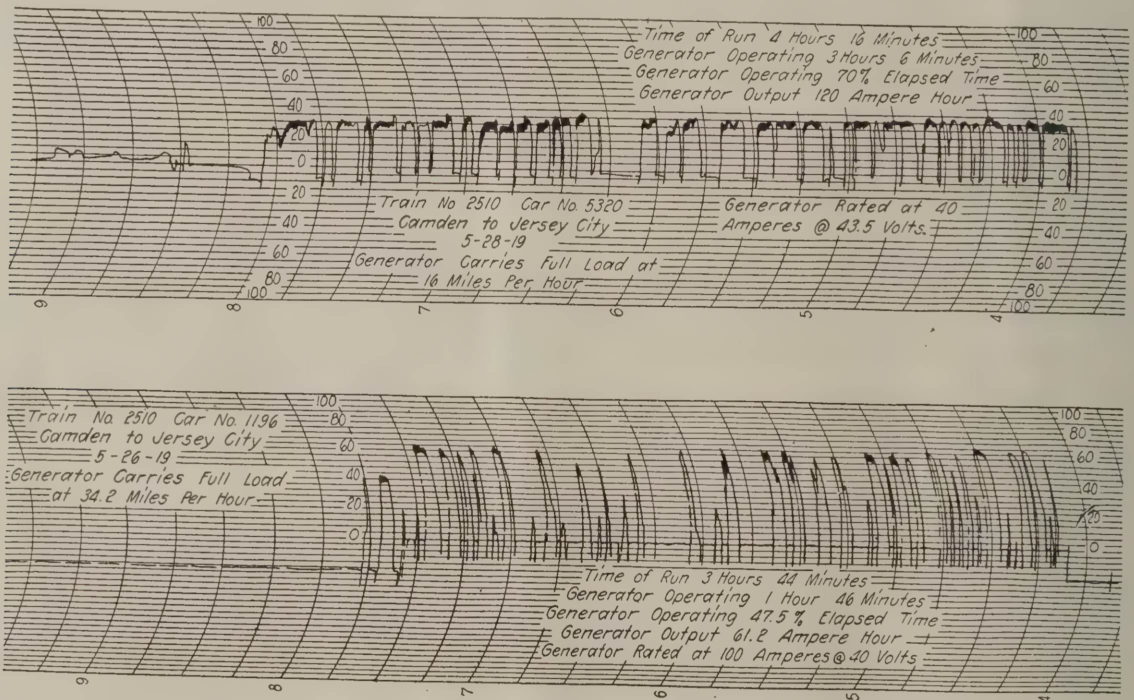
When theory is reduced to practice, a number of factors, such as clearance, practical pulley ratios, belt strength, etc., operate to reduce greatly the number of practical solutions.

Your committee considers that experience has demonstrated that the following combination will cover the entire field:

Class of service	Approximate maximum load demand	Ampere hour capacity of battery Min.	Max.	Ampere capacity of generator	Minimum full load speed M.P.H.
Official, sleeping, parlor, mail and dining cars having heavy lighting loads, or severe operating conditions	50	350	600	100	26
Mail, dining cars, etc., where the lighting loads are not so heavy or the operating conditions so severe......	35	300	350	75	26
Coaches, passenger baggage cars, baggage cars under average operating conditions	25	200	300	50	21
Same cars as next above operating in slow speed branch line or local service	25	150	225	50	16

It is, however, an open question as to how far to apply this table. The question should be determined by each railroad from a study of the conditions under which their cars must operate; giving full consideration to the first cost of equipment, value of stock to be carried for repair, etc.

For instance, if the conditions on any road are such that the majority of cars require, for successful lighting, an axle generator having a minimum full load speed of, say, 16 miles per hour, and conditions of operation are such that the cars are liable to be transferred from one class of service to another, it would seem desirable to make all generators of the one design, even though the first cost of some of the generators was greater than necessary. The advantage of no restrictions on the operating department in the manipulation of the cars and of having one type of



Figs 12 (above) and 13—Curves Showing the Effect of Very Low and Very High Values of the Minimum Full Load Speeds of Generators Operating in the Same Train

generator and the decrease in the amount of repair parts to be carried in stock should outweigh the additional first cost.

On the other hand, if the cars are restricted to certain runs and if the requirements of the service indicate that a considerable number of cars require generators having minimum full load speed of 21 miles per hour or both 21 and 26 miles per hour, it might be desirable to have generators of different minimum full load speed. As an aid in deciding the question, we attach time current curves, Figs 12 and 13, showing the effect of very low and very high values of the minimum full load speeds of generators operating in the same train; and also curves showing the variation in cost price, Fig. 14, on a percentage basis, of complete axle generator equipment with respect to minimum full load speeds in r.p.m. of the armature shaft.

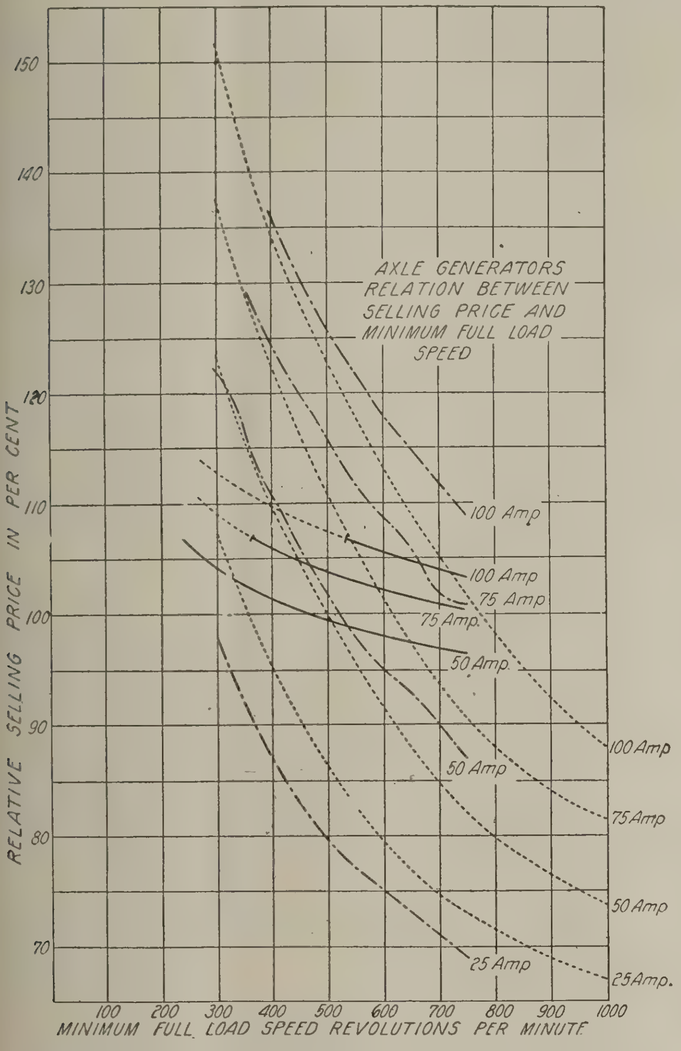


Fig. 14—Curves Showing Relation Between Selling Price and Minimum Full Load Speed of Axle Generators

In these latter curves the full lines represent one make of axle generator, the dotted lines another, etc.

In each set of curves the 50 ampere generator at a minimum full load speed of approximately 500 r.p.m., has been taken as 100 per cent cost price. It should be noted that the 100 per cent cost price in dollars for one make of generator bears no relation to the cost in dollars of any other make of generator.

Generator Regulator

While the fundamental idea on which axle generator regulation is based is practically the same for all generators, except those of the controlled speed type, the manner in which the idea is actually worked out is so varied that your committee is unable to word a specification which will cover all the methods employed. The results that are to be attained by means of the type of regulation that may be employed can, however, be defined.

Lamp Voltage Regulator

In like manner the means employed to obtain lamp voltage regulation are also too varied to permit covering same in a specification. The voltage limits within which a properly designed lamp voltage regulator should work can, however, be stated. Curves showing the regulation obtained from regulators properly adjusted are shown on Fig. 15.

Main Generator Fuse Clips

It is desirable that the various pieces of apparatus that are mounted upon the generator regulator and lamp regulator panels may be removed and reapplied without it being necessary to remove the panel from its support.

The contacts of the generator main fuse in the armature circuit now shown in Fig. 19, Page 166, Vol. 9, 1916, are one of the parts that it is necessary to renew. To comply with the above recommendation, your committee submits drawing No. 16, showing a main fuse contact on which the clips can be removed without disturbing the panel.

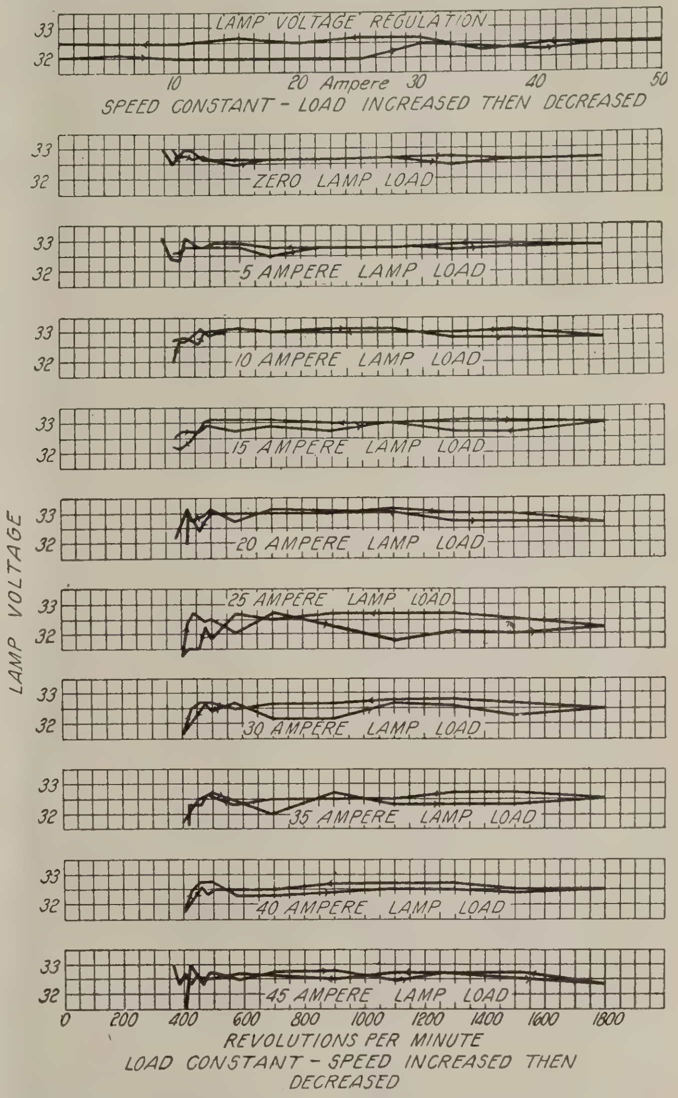


Fig. 15—Curves Showing the Regulation Obtained From Properly Adjusted Lamp Voltage Regulators

Regulator Adjustments for Different Types of Battery

In former years the lead-acid-lead battery was used exclusively in car lighting service, but of late the nickel-alkali-iron battery is also used.

The charging characteristics of the two types of battery are radically different and it appears advisable that the generator regulator be so constructed that they may readily be adjusted to suit either type of battery.

Your committee in its 1919 report, recommended that the net ampere capacity of an axle generator be based upon a maximum observable rise in temperature of 70° and 110° C, instead of the corresponding figures of the American Institute of Electrical Engineers of 65° C and 105° C, respectively.

This was done under a misapprehension of the true meaning of the A. I. E. E. figures and because a comparison of similar tests run on road and bench indicated that on the road the generator would operate at a temperature several degrees lower than on the bench. On looking into the matter further, your committee feels that the criticism is well founded.

The A. I. E. E. standardization rules specify that the rating of motors and generators shall be based upon a maximum observable rise in temperature of 65° C and a maximum observable temperature of 105° C when class "A" insulation is used, the rating taking no account of the conditions of service.

The A. I. E. E., however, recognizes, especially in the case of railway motors, which in their service conditions are more nearly comparable to an axle generator than any other class of motor, that there is a difference between the temperature at which a machine is rated and the temperature at which it may be allowed to operate.

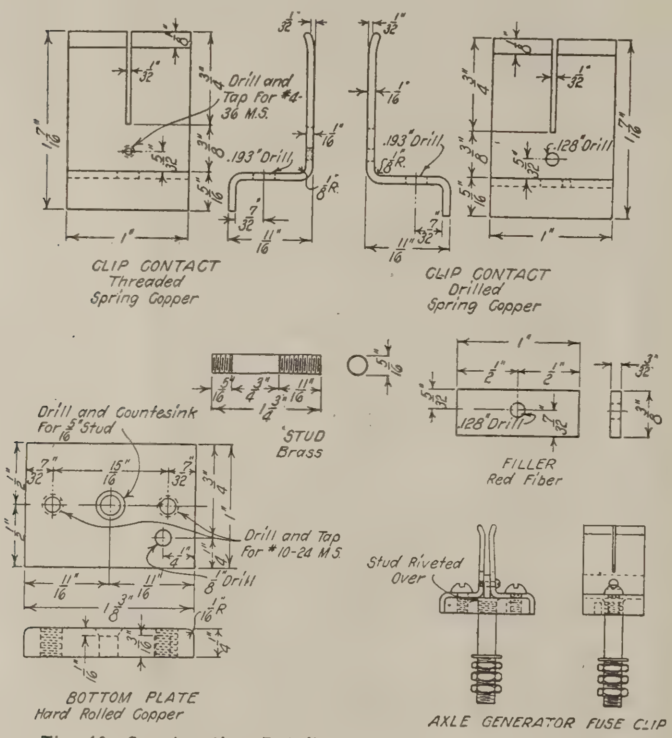


Fig. 16—Construction Details of Axle Generator Fuse Clip

Therefore, your committee has, in submitting these specifications, used the standard temperature values of the A. I. E. E., but would call attention to the fact that under similar conditions of test an axle generator will operate several degrees cooler on the road than on the bench.

Having discussed the various features that must be considered, your committee herewith presents the following specifications for axle generators:

Specifications for Axle Generators

1. General.—(a) This specification is intended to cover axle generator equipment for the A. B. and C. Railroad, delivery to be made f. o. b. manufacturers' works.

(b) Submission of bid will be understood to imply that the manufacturer fully understands and accepts the requirements imposed by, and will furnish apparatus which will comply with, this specification.

(c) These axle generators are intended for service on cars having a total load, lamps, fans, etc., of......amperes at 32 volts. Each car will be equipped with......cells of battery of...... ampere hours capacity.

(d) The generator shall carry full load at......miles per hour.

Note.—The railway company shall specify whether the lead-acid-lead or nickel-alkali-iron battery will be used.

(For recommended values of minimum full load speeds, see below.)

Class of service	Approximate maximum load demand	Ampere hour capacity of battery Min.	Ampere hour capacity of battery Max.	Ampere capacity of generator	Minimum full load speed M.P.H.
Official, sleeping, parlor, mail and dining cars having heavy lighting loads, or severe operating conditions.	50	350	600	100	26
Mail, dining cars, etc., where the lighting loads are not so heavy or the operating conditions so severe......	35	300	350	75	26
Coaches, passenger-baggage cars, baggage cars under average operating conditions	25	200	300	50	21
Same cars as next above operating in slow speed branch line or local service	25	150	225	50	16

(e) The material and workmanship shall be the best of their respective kinds.

(f) The accredited representative of the A. B. and C. Railroad shall be the sole judge, on all questions that are not capable of measurement and record, as to whether or not the apparatus complies with the specification.

(g) The apparatus to be furnished shall consist of:

Axle Generator.
Axle Generator Pulley.
Generator Leads.
Generator Lead Terminal Block (to be mounted on car body).
Generator Suspension.
Generator Regulator (with corner brackets).
Lamp Voltage Regulator (with corner brackets).
Axle Pulley.
Axle Pulley Bushing.
Belt and Fasteners.
Lamp Circuit Distributing Panel.

Note.—Any item not desired shall be crossed out.

2. *Axle Generator.*—(a) The axle generator suspension lugs shall be of such design and cross section as to eliminate, as far as possible, liability to blow holes, bubbles or other manufacturing defects which may tend to weaken the material in the lug or section of frame adjacent to the lug.

The holes in the lug shall not be cored. The design and location of the lug shall be approved by the railroad company. Where there is movement of suspension links or pins in the lugs, the hole in the lugs shall be suitably bushed, the bushing being placed in the lug in such manner that it cannot be lost or move relative to the lug.

(b) The generator frame, pole pieces and end housings shall be machined so that all are in accurate alignment and interchangeable from one generator to another of the same make, size and type.

(c) The end housings shall be machined for the ball bearings with allowance for fit as given below:

HOUSING FITS

Bearing No.	Nominal	Outside diameter, in. Maximum	Outside diameter, in. Minimum	Allowance, in. Maximum	Allowance, in. Minimum
304	2.0473	2.0473	2.0465	+.0026	+.0008
307	3.1496	3.1496	3.1488	+.0026	+.0008
308	3.5433	3.5433	3.5425	+.0026	+.0008
312	5.1181	5.1181	5.1173	+.0030	+.0012
407	3.9370	3.9370	3.9362	+.0030	+.0012
409	4.7244	4.7244	4.7236	+.0033	+.0015
412	5.9055	5.9055	5.9043	+.0037	+.0015

Above allowances are based on a total tolerance of 0.0010 in. for housing bore.

(d) The armature shaft shall be annealed carbon steel having characteristics equal to or better than the following:

Carbon .... 0.38 to 0.52 per cent.
Manganese .... 0.40 to 0.75 per cent.
Phosphorus (not more than)...... 0.05 per cent.
Sulphur (not more than)......... 0.05 per cent.
Tensile strength, lbs. per sq. in. (not less than)...80,000.
Yield Point, lbs. per sq. in. (not less than) 0.5 tensile strength.
Elongation in 2 in., per cent inverse ratio, 1,800,000 ÷ tensile strength.
Elongation in 2 in. (not less than)..........20 per cent.
Reduction in area (not less than)..........32 per cent.
Reduction in area, per cent inverse ratio, 2,800,000 ÷ tensile strength.

Note.—See specification of the Railway Master Mechanics Association for annealed carbon steel, Vol. L, 1917-1918, page 254.

(e) The armature shaft at the fits for the inner race of the ball bearings will preferably be ground to the diameter with allowable tolerances as given below for the size of ball bearings to be used.

SHAFT FITS

Bearing No.	Bore		Pressed fit allowance, in.				Sliding fit allowance, in.	
	Nominal	Max.	Min.	Max.	Min.	Desired	Max.	Min.
304	0.7874	0.7876	0.7870	+.0011	+.0001	+.0003	—.0001	—.0011
307	1.3780	1.3782	1.3776	+.0012	+.0002	+.0005	—.0001	—.0011
308	1.5748	1.5750	1.5744	+.0012	+.0002	+.0005	—.0001	—.0011
312	2.3622	2.3624	2.3617	+.0015	+.0004	+.0007	—.0001	—.0012
407	1.3780	1.3782	1.3776	+.0013	+.0003	+.0006	—.0001	—.0011
409	1.7717	1.7719	1.7713	+.0014	+.0004	+.0007	—.0001	—.0011
412	2.3622	2.3624	2.3617	+.0017	+.0006	+.0010	—.0001	—.0012

Above allowances are based on a total tolerance of 0.0004 in. for shaft diameter at fit.

Should the bearing be mounted on the shaft by means of an expansion device instead of a press or sliding fit, this expansion device shall be so constructed as to relatively secure the bearing to the shaft and to lock positively under any and all service conditions.

(f) The armature shaft for all axle generators at the pulley fit shall conform to the dimensions shown in Figs. 1 and 2, Pages 85 and 86, Vol. 10, 1918.

(g) The armature shaft pulley nut shall be of the........lock-ing nut type. The face of the nut adjacent to the hub of the pulley shall be finished square with the axis of the thread.

(h) The armature, as a whole, shall be designed as a unit to permit the ready renewal of the shaft without disturbing any part of the winding.

(i) The commutator bars shall be hard-drawn, drop forged or cast-swedged copper with solid risers. The insulation between bars shall be high grade mica of such design and quality as will wear at the same rate as the bars. The commutator bars shall be insulated from the shell by built-up forms of high grade mica.

The commutator shall be thoroughly seasoned and securely fastened on the shell.

The armature conductors shall be of copper, insulated, preferably with American Institute of Electrical Engineers Class "B" insulation.

(j) Bearings shall be of the annular ball type and of the size specified as follows:

The field coils shall be form wound, impregnated with a suitable insulating compound to conform to established practices of electrical manufacturers, or thoroughly saturated by the dipping process with insulating material and then baked. The coils shall be covered with at least two layers of insulating tape laid with a half lap. The ends of each coil shall be marked to indicate the inner and outer ends of the coil. The coil shall be placed over the pole pieces and so held as to prevent positively any relative movement of the coil with respect to the pole piece.

(n) The pole changer shall be of such design as to throw completely, from one position to the other, in not more than ten revolutions of the armature shaft.

(o) The armature pulley shall be......in. in diameter in accordance with A. R. E. E. Drawing No........and is intended to be driven by a....in. ....ply belt from an axle pulley....in. in diameter.

(p) Main generator and field leads shall be not less than 40 in. long and shall consist of No. 4 A. W. G. cable of not less than 61 strands, 4/64 in. wall of 30 per cent Para rubber insulation, or equivalent, covered with two braids.

(q) The generator shall be designed to generate rated voltage (40 volts) at load side of generator regulator and to carry full load, ...amperes (net current capacity, that is, total current generated, less all field, control and regulating current used in the generator, generator regulator and lamp voltage regulator), at an armature speed not to exceed ......r.p.m.

$$\frac{560}{60} \times \frac{\substack{\text{Diam. Axle Pulley x Min. full load} \\ \text{Diam. Armature Pulley}}}{\text{speed of car in miles per hour}} = \text{r.p.m. of armature shaft.}$$

This value shall be known as the "minimum full load speed" in r.p.m. of the generator. (For recommended values in miles per hour see table in Section 1-d.)

(r) The generator, with an armature r.p.m. of not more than 75 per cent of the above speed, shall generate sufficient voltage and current to close the automatic switch at the voltage setting as given for same, this speed being known as the "cutting in speed" in r.p.m.

(s) The generator shall be safe to operate both electrically and mechanically at an armature r.p.m. of

BODY SUSPENDED.

Width of Belt Required to Transmit Necessary Power.

Truck Suspended		Free Speed.						Controlled Speed.			
		5 In.		4 In.		3 In.		4 In.		3 In.	
Pulley	Comm.	Pulley	Comm.	Pulley	Comm.	Pulley	Comm.	Pulley	Comm.	Pulley	Comm.
412	412	412	*412	409	*409	407	407	312	312	307	307
....	....	....	‡409	....	‡407	....	....	....	‡308	....	‡304

*Preferred. ‡Alternate.

Bearings shall conform to the following dimensions with the allowance and tolerance as given: (S. A. E. Standard).

Bearing No.	Inside Diameter Inches.			Outside Diameter Inches.			Width Inches.			Eccentricity Tolerance's Inches.	
	Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.	Min.	Inner.	Outer.
304	0.7874	0.7876	0.7870	2.0473	2.0473	2.0465	0.5906	0.5906	0.5856	0.0006	0.0012
307	1.3780	1.3782	1.3776	3.1496	3.1496	3.1488	0.8268	0.8268	0.8218	0.0008	0.0012
308	1.5748	1.5750	1.5744	3.5433	3.5433	3.5425	0.9055	0.9055	0.9005	0.0008	0.0012
312	2.3622	2.3624	2.3617	5.1181	5.1181	5.1173	1.2205	1.2205	1.2155	0.0010	0.0016
407	1.3780	1.3782	1.3776	3.9370	3.9370	3.9362	0.9843	0.9843	0.9793	0.0008	0.0012
409	1.7717	1.7719	1.7713	4.7244	4.7244	4.7236	1.1417	1.1417	1.1367	0.0010	0.0016
412	2.3622	2.3624	2.3617	5.9055	5.9055	5.9044	1.3780	1.3780	1.3730	0.0010	0.0016

(k) One end bearing shall be mounted so that the bearing shall have approximately 0.01 in. play in the longitudinal direction of the shaft. The other end shall be mounted so that it shall have at least 1-16 in. play in the longitudinal direction of the shaft.

(l) The end housing shall have one or more circular U-shaped grooves machined in the bore through which the shaft passes; and felt washers, fitting the shaft snugly, shall be applied to the inner side of the commutator end housing and to both sides of the pulley end housing.

(m) The field coils shall be wound with copper, insulated, preferably with the Class "B" insulation of the American Institute of Electrical Engineers.

$$\frac{560}{60} \times \frac{36}{33} \times \frac{\text{Diam. Axle Pulley x 75 x Factor of Safety 1.2}}{\text{Diam. Armature Pulley}} = \text{Max. Armature r.p.m.}$$

This value shall be known as the "maximum speed" in r.p.m. of the generator.

(t) At all speeds from cutting in to maximum speed, and at all loads from zero to full rated net ampere capacity, the generator shall operate without destructive or excessive sparking at the brushes, and the armature and armature pulley shall rotate in good mechanical balance.

(u) The generator shall be capable of delivering rated net amperes within a range of 37 to 48 volts. (This requirement is not intended to conflict with the heat test.)

3. *Suspension.*—(a) The generators shall be .... suspended. (The Railroad Company shall insert "truck" or "body.")

(b) The suspension shall be in accordance with the following drawings of the A. B. and C. Railroad, which are hereby made a part of this specification, or they may be in accordance with the manufacturers' standard if the railroad company so elect. (List drawings or cross out section applying to same.)

4. *Belt Tension Device.*—(a) The belt tension device shall be in accordance with the following drawings of the A. B. and C. Railroad, which are hereby made a part of this specification, or they may be in accordance with the manufacturers' standard if the railroad company so elect. (List drawings or cross out section applying to same.)

5. *Generator Regulator.*—(a) The generator regulator panel shall be composed of a non-conducting, non-combustible material having a horizontal dimension of 16 in. and a thickness of at least ¾ in.

(b) The panel shall have four holes drilled in same for the supporting bolts. These holes shall be 7/16 in. in diameter and located 1 in. from the sides and 1 in. from the ends of the panel, giving a horizontal distance, center to center of these holes, of 14 in. (Should it be desired to use a corner bracket with the panel, same shall have the supporting bolt holes drilled 7/16 in. in diameter and so located that when mounted on the panel the horizontal distance between center of holes is 14 in. For attachment to the panel the corner bracket shall be drilled and tapped for a ⅜-in. bolt having 16 threads per in.)

(c) The terminals on the generator regulator panel shall be arranged so that, in a horizontal direction, the positive is at the right and in a vertical direction the positive is at the top.

(d) Each terminal shall be stamped for identification and polarity.

(e) There shall be included with the generator regulator panel, wire terminals for attachment of the wires to the panel terminals; these wire terminals being stamped to correspond to the panel terminals to which they are to be connected.

(f) The apparatus will, preferably, be so mounted on the panel that it may be removed and reapplied without it being necessary to remove the panel from its supports.

(g) The connections between the various pieces of apparatus on the panel shall be, so far as is possible, on the back of the panel and preferably soldered after final adjustment has been made.

(h) The panel shall be supported by four ⅜-in. bolts having 16 threads per inch.

(i) Fuses, fuse contacts and fuse terminals shall conform to A. R. E. E. Standard practice.

(j) The generator regulator automatic switch shall be set to close at any and all operating temperatures at not more than 34 volts, this voltage being attained by the generator at not more than 75 per cent of minimum full load speed.

(k) The automatic switch must open and close without chattering, pumping, sticking or excessive arcing.

(l) The generator regulating apparatus and battery protective devices shall be of such design as to perform satisfactorily all the following functions:

1. Close the main circuit of the generator, by means of an automatic switch, in order to permit current to flow from the generator to the battery and lamps whenever the generator develops proper voltage.
2. Open the main circuit of the generator, by means of an automatic switch, in order to prevent the discharge of the battery through the generator when the r.p.m. of the armature has decreased to a point where its voltage is less than the battery voltage.
3. Automatically prevent the overloading of the generator.
4. Automatically control the rate of charge of the battery.
5. Automatically prevent overcharging the battery either in amperes or ampere hours.
6. In case of open battery circuit the generator shall continue to carry the lamp load and the generator regulator shall automatically prevent an excessive rise of voltage on the equipment.
7. Means will preferably be provided whereby the adjustment of the regulator can readily be changed from the voltage and current suitable for a lead-acid-lead battery to the voltage and current suitable for a nickel-alkali-iron battery of the same ampere hour capacity, the voltage being capable of being varied independently in the latter case from 1.72 to 1.8 to 1.88 per cell to take care of temperature conditions.
8. For any given condition of battery with any variations of speed at and above 150 per cent of minimum full load speed the regulator shall maintain regulation within 5 per cent, plus or minus, of the value for which the regulator is set for operation. This value to apply equally whether the type of regulation is potential, current, watts or any combination of same.
9. When submitting proposition, the axle generator manufacturers shall describe in detail the type of control of generator output and battery charging that they propose to furnish, submitting such curves as are necessary to afford a complete explanation.

Note—Railroads may substitute for section 5-1 detailed specifications covering such type or types of regulation that they desire to consider, provided that the limits are not greater than those given in this specification.

6. *Lamp Regulator.*—(a) The lamp regulator panel shall be composed of a non-conducting, non-combustible material having a horizontal over all dimension of 16 in. and a thickness of at least ¾ in.

(b) This panel shall have four holes drilled in same for the supporting bolts. These holes shall be 7/16 in. in diameter and located 1 in. from the sides and 1 in. from the ends, giving a horizontal distance, center to center of these holes, of 14 in. (Should it be desired to use corner brackets with the panels, same shall conform to the requirements as given under "Generator Regulator.")

(c) The terminals on the panels shall be so arranged that, in a horizontal direction, the positive is at the right, and in a vertical direction the positive is at the top.

(d) Each terminal shall be stamped for identification and polarity.

(e) There shall be included with the lamp regulator panel, wire terminals for attachment of the wires to the panel terminals, these wire terminals being stamped to correspond to the panel terminals to which they are to be connected.

(f) All apparatus will preferably be so mounted on the panel that it may be removed and reapplied without it being necessary to remove the panel from its supports.

(g) The connections between the various pieces of apparatus on the panel shall be, so far as is possible, on the back of the panel and, preferably, soldered after final adjustment has been made.

(h) The panel shall be supported by four ⅜-in. bolts having 16 threads per inch.

(i) The lamp regulator shall be so designed that with the complete equipment operating in the normal manner, on bench test or in service, it will maintain the voltage across the lamp mains on the load side of the regulator under the conditions of test as specified below, within the following limits:

1. With the battery discharging and with the battery voltage 31 volts or less, the drop in voltage across the lamp regulator resistance shall not exceed one volt with 40 amperes flowing.
2. With armature r.p.m. increasing at an approximately uniform rate from minimum full load speed to maximum speed in not more than five minutes and again decreasing to its original value, the voltage shall be maintained at....volts, plus or minus one volt at any current value not exceeding 40 amperes.
3. With the armature r.p.m. held constant at any given speed between the limits of minimum full load speed and maximum speed, and with the current instantaneously varied by 5 ampere steps, both increasing and decreasing, the voltage shall be maintained at ....volts plus or minus one volt.
4. Conditions 2 and 3 shall be complied with under any condition of charge of battery.

Note.—Insert value at which it is desired voltage shall be maintained.

7. *Net Ampere Capacity.*—(a) The generator shall have a net ampere capacity of ....amperes. (Net ampere capacity equals total current generated less all current used by fields, con-

trol, generator regulator and lamp regulator. For recommended values see Section 1-d.)

8. Heat Test—(a) Connect the generator, generator regulator and lamp regulator (if used) in the normal manner, using rheostat or lamp bank in the battery and lamp circuits.

(b) Remove hand hole covers and operate generator continuously for five hours at the armature r.p.m. corresponding to minimum full load speed with the generator delivering continuously ....net amperes at 40 volts.

(c) Under the above conditions, and with temperatures measured by the thermometer method, no part shall at any time attain a temperature higher than the values given below:

	Insulation A.I.E.E. classification			
	Class "A"		Class "B"	
Part of apparatus	Maximum observable temperature degrees C.	Maximum observable rise in temperature degrees C.	Maximum observable temperature degrees C.	Maximum observable rise in temperature degrees C.
Any part of generator regulator, except resistance units, carbon piles, commutator, brushes, brush rigging and bare copper solenoids	105	65	125	85
Commutator, brushes, brush rigging and bare copper solenoids.	125	85	125	85

(d) Bearings.—Maximum observable temperature 65° C.

(e) The net ampere capacity shall be determined by the maximum net amperes that can be generated without the above temperature being exceeded.

9. Insulation Test.—(a) Immediately after the heat test all parts of the equipment shall withstand, without breakdown, an alternating potential of 1,000 volts, applied between conductors and ground, for a period of one minute, all metallic parts except conductors being grounded.

10. Badge Plate.—(a) Each generator shall have attached to it a badge plate on which the following information shall be shown:

1. Manufacturer's name.
2. Manufacturer's type and serial number.
3. Nominal voltage.
4. Rating in amperes.
5. Minimum full load speed in r.p.m.
6. Pulley ratio. (Example, 2 to 1.)

11. Rejection.—The A. B. C. Railroad reserves the right to reject:

(a) Any equipment, or part thereof, that fails to comply with the requirements of the specification when inspected at time of delivery.

(b) Any equipment, or part thereof, that is defective in any way (material, workmanship or details of design) which might reasonably have been overlooked when approving the plans.

(c) Any equipment, or part thereof, that is responsible for an excessive number of failures in service, or that is found to be defective in material or workmanship within one year of date of delivery.

12. Patents.—(a) The manufacturer shall insure the A. B. & C. Railroad against any and every loss arising from claim that the apparatus, as furnished, infringes patents not owned or controlled by the manufacturer and shall furnish the A. B. & C. Railroad, when requested, a satisfactory bond to cover such contingency.

13. Guarantee.—(a) The manufacturer shall correct, without charge to the A. B. & C. Railroad, any defect due to design, material or workmanship which develops within one year from date of delivery of the equipment.

14. Data.—(a) Dimension drawings in as full detail as may be necessary to afford thorough understanding of the equipment offered shall be submitted to and approved by the A. B. & C. Railroad before manufacture is begun.

15. Shipment.—(a) No equipment shall be shipped until same has been accepted by the A. B. & C. Railroad or inspection waived and shipment authorized.

Note—The railroad company when requesting bids shall fill in all blanks indicated thus: ....

With the reference to the subject of increasing the inside height of battery boxes, your committee finds there is a tendency in the improvement in the design of lead storage batteries to increase their height, particularly for the larger capacities to provide greater sediment and acid space. To do this will involve increasing the height of the majority of battery boxes now in use, particularly if sufficient space is to be provided to permit inspecting and flushing of batteries without withdrawing them. Your committee has sent out a questionnaire to secure information as to recommended space that should be provided and will submit recommendations on this subject at the annual meeting.

Your committee recommends the following:

That the reports be received as submitted, and that the specification in its entirety be submitted to letter ballot, it being recognized that if the specification is accepted, it will automatically supersede recommendations in previous reports that conflict with the specification.

Committee: L. S. Billau, chairman (assistant electrical engineer, B. & O.); F. J. Hill (chief electrician, car department, Michigan Central); E. W. Jansen (electrical engineer, Illinois Central); E. Lunn (chief electrician, Pullman Company); A. McGary (chief electrician, New York Central); C. H. Quinn (chief electrical engineer, Norfolk & Western); J. R. Sloan (chief electrician, Central Region P. R. R.); A. E. Voigt (car lighting engineer, A., T. & S. F.); E. Wanamaker (electrical engineer, C. R. I. & P.).

Discussion on the Train Lighting Report

In opening the report of the Committee on Train Lighting Equipment and Practice for discussion, Mr. Billau, chairman of the Committee, admitted that the report had purposely been drawn up in a more or less flexible manner in order that its specifications should not be so rigid as to interfere with practices that the various roads had found necessary. In other words, considerable latitude was permitted in the specifications for axle generators, in order that certain roads could make these specifications suit their needs. One of the points in the specifications which called forth much comment, but which could scarcely be considered worthy of the time consumed on it, inasmuch as the conditions involved would be decidedly rare, was in connection with a generator regulator. The report was worded to read as follows: "In case of open battery circuit the generator will continue to carry the lamp load and the generator regulator shall automatically prevent an excessive rise of voltage on the equipment." Voluminous discussion arose over what should be considered as "excessive." It was finally disposed of by voting that the "generator regulator shall automatically prevent a rise of voltage over 20 per cent of lamp voltage." Other minor corrections and changes were discussed at too great length, especially when it was taken into consideration that the specifications were presented in a more or less flexible form in order to cover a wide variety of conditions.

Report of Committee on Electric Headlights

As locomotive headlight equipment is at present undergoing a rapid and extensive development it is the thought of your committee that their work since the October, 1919, convention be reported in the nature of a progress report at this time rather than attempting to present a report in which definite recommendations are offered with respect to standardization of design, operation, etc. There are two features of the utmost importance in this connection which are matters on which widely divided opinions are entertained and it is essential that the association investigate and develop these matters fully in order that suitable recommendations may be made for adoption as standard practice: 1, a headlight lamp for locomotives in switching service, and 2, locomotive signal lamps for classification lamps and markers. In regard to the former, in the absence of reliable test data, and in order that new light may be thrown on the subject, the National Lamp Company, through their Commercial Development Department, have very kindly offered to devote their facilities in connection with a number of new lamps which they are developing, in co-operation with the work of the Headlight Committee, and will conduct a series of tests at Nela Park, Cleveland, in the near future, which tests are designed to assist the association in arriving at a conclusion as to what should be recommended on this very important matter. Regarding the latter, as this is strictly a train operating matter, but involving engine terminal practice of vital importance, this committee feels that the A. R. A. Headlight Committee should be urged to accept the recommendation that the train operating rules be so revised or modified as to conform to the changed conditions incidental to the general use of electricity for lighting on locomotives, and to agree to the use of a lamp which would be a combination classification and marker lamp;

the lamps to be wired permanently in their respective locations on the locomotives to obviate the difficulties which are inevitable in attempting to maintain a circuit to the ends of the pilot beams for marker lamp service as is now required.

As the work of the committee is necessarily still far from being finished, with respect to complete recommendations regarding standard practice, it is felt the committee should be continued and the necessary research work carried on with the view to having ready for presentation at the next annual convention recommendations as complete as possible covering practice which might be considered standard for present-day equipment and under present conditions.

The Headlight Committee of the A. R. A., Mechanical Section, held a meeting at Chicago on January 28, at which meeting our chairman, E. W. Jansen, was requested by the former committee to be present.

Your committee therefore held a meeting on January 26 in the office of the chairman, to outline a programme and with a view to guiding Mr. Jansen in his discussion with the A. R. A. Committee.

A second meeting of your committee was held in the office of the chairman on March 19, and the work of the previous meetings reviewed, matters of new business taken up and an outline agreed upon for the present progress report.

It is felt that the recommendations with respect to type and capacity of turbo-generator, its steam pressure range, mounting, etc., should be caused to stand. The base-plate, drilling, etc., recommended in the 1919 report, should be adhered to for present equipment, and a three-point support should be recommended, fixing the bolt hole spacing and size of bolts for new turbo-generator design.

No change should be made in our recommendations as to ball bearings and brush sizes. After further discussion and development of the steam and drain pipe question, it is felt that three-quarter inch pipe is advisable for these features in order to provide necessary mechanical strength and that not less than two inch pipe be used for the exhaust pipe. It is further recommended that where screens are now used in this pipe that the screens be removed and, if necessary, to so change the shape of the exhaust as to render it impossible for cinders, etc., to get into this pipe. In cases of turbines having side exhaust outlets a suitable flanged fitting should be used instead of screw fittings, and it is recommended that the flanged fitting be provided with 6 bolts to permit mounting the exhaust pipe in any desired position. In order to accomplish this, three stud bolts should be located in the turbine casting and six bolt holes in the flanged fitting. The bolts to be not less than three-eighths inch diameter.

No change should be made in the recommendation regarding lubrication, as opinions of the various railroads are divided on the matter of grease or oil for lubrication and the turbo-generator should be so designed as to accommodate either type.

It is recommended that the so-called A. S. M. E. thread should be standardized for electric headlight service. This standard, now used by many railroads, contemplates the use of machine screw threads (A. S. M. E. standard) for sizes smaller than one-quarter inch diameter and bolt threads (A. S. M. E. standard) for one-quarter inch diameter, and larger.

It is proposed that the recommendation covering conduit and wiring be modified to cover condulet fittings or preferably malleable iron or pressed steel specially designed for the particular service in order to overcome so far as possible breakage as is experienced with the present cast iron condulet fittings.

No change should be made in the recommendation regarding the 250 watt headlight lamp for locomotives in road service. The question with respect to the headlight lamp for locomotives in switching service, however, should be held open until the completion of the tests which are to be conducted in the near future by the National lamp works at Cleveland.

In connection with the cab lamp, it is recommended that a 15 watt 33 volt, S-17 bulb with the same light center length as the 34 volt lamp be used in preference to a 10 watt lamp in the cab and all outlets other than the headlight lamp.

In connection with classification and marker lamps it is felt that the A. R. A. Headlight Committee should be prevailed upon to accept the recommendation to the effect that the train operating rules be so revised or modified as to permit the use of a combination marker lamp which may be wired permanently in position on the locomotive and tender in order to eliminate the transferring of classification lamps from the smoke box to the pilot beam when required for marker service. This combination lamp could be a standard design and arrangements could be made for its manufacture by any or all of the railroads and manufacturers of railroad equipment.

It is also recommended that a standard design of plug and receptacle be agreed upon for the use of such railroads as desire to use detachable signal lamps and that arrangements be made so that this plug and receptacle can be manufactured by anyone who so desires.

The matter pertaining to the use of a more efficient reflector is receiving very careful investigation and in this connection a high grade ground glass reflector shows promise of being very well adapted to the requirement. Your committee is giving this matter very careful consideration and after the headlight tests have been conducted at Cleveland, at which time it is the desire that a variety of reflectors be tested, it is hoped that a definite recommendation may be made in the final report on the headlight subject.

In connection with new business and with respect to the polarity of the headlight generator, it is recommended that on all direct current generators, the positive terminal post be permanently marked with the usual plus positive sign and to be the terminal post on the right side of the vertical axis. If the terminal posts are mounted on the vertical axis the positive post should be the upper when facing the commutator.

In connection with the matter of wiring it is the thought of the committee that a type of connector cable should be developed by the wire manufacturers which will be suitable for the connection between the locomotive and tender. Such a cable to be comparatively inexpensive and the design to provide flexibility and the necessary weather proof qualities required for the exposed and severe conditions, the matter of dialectric strength of the insulation to be of secondary consideration to that of its flexibility and weather proof characteristics.

Committee:—E. W. Jansen (electrical engineer, I. C.), chairman; L. C. Hensel (electrical engineer, St. L. & S. F.); C. R. Sugg (electrical engineer, A. C. L.); J. L. Minick (assistant engineer, Pennsylvania Lines); G. E. Murray (electrical and mechanical engineer, Grand Trunk); F. J. Hill (chief electrician, Michigan Central); G. B. Colgrove (chief electrician, I. C.); J. A. Andreucetti (assistant electrical engineer, C. & N. W.); H. R. Pennington (supervisor, welding and electrical equipment, C. R. I. & P.); C. O. Watson (chief electrician, C. & O.); L. C. Muelheim (headlight supervisor, B. & O.).

Discussion of the Headlight Report

The discussion of the report of the Committee on Electric Headlights was brief. From present indications it was seen that much of the headlight equipment has still a long way to go before it could be considered as standardized in all of its features. The situation was summed up by J. L. Minick of the Pennsylvania Railroad, who is a member of the headlight committees of both the American Railroad Association and the Association of Railway Electrical Engineers.

Report of Committee on Illumination

Your committee submits the following as a progress report:

1. *Changes in Method of Rating Train Lighting Lamps.*—The present basis of rating of train lighting lamps is to maintain the lumen output constant and vary the actual wattage as changes in efficiencies occur. For a number of manufacturing reasons it is desired to change the method to that in which the watts will remain constant and the light output vary with changes in efficiency, this being the standard method of rating for all other classes of multiple burning lamps. The present and proposed ratings for the train and cab lighting lamps are as follows:

TABLE OF PRESENT AND PROPOSED RATINGS

TRAIN AND CAB LIGHTING LAMPS

MAZDA "B"

Present (Data Book)								
Nom. Watts	Computed Actual Watts	Bulb	Lumens	Watts Per H.C.P.	Watts Per S.C.P.	Actual Watts	Proposed Lumens	Per cent Change Watts
				25-34 Volts				
10	9.06	S-17	85	1.06	1.34	10	94	10.35
10	9.74	G-18½	85	1.17	1.44	10	87	2.67
15	13.03	S-17	125	1.03	1.31	15	144	15.1
15	13.72	G-18½	125	1.10	1.35	15	137	9.33
15 (cab)	15.31	S-17	125	1.22	1.54	15	122	—2.02
20	17.97	S-17	175	1.02	1.29	*20	195	11.3
20	18.95	G-18½	175	1.10	1.36	*20	185	5.54
25	25.65	S-17	250	1.02	1.29	25	244	—2.53
25	27.05	G-18½	250	1.10	1.36	25	231	—7.58
50	51.30	S-19	500	0.98	1.24	50	506	—2.52
50	48.50	G-30	500	1.00	1.22	50	515	3.09

			50-65-Volts					
15	13.72	S-17	125	1.08	1.37	15	137	9.33
15	14.32	G-18½	125	1.17	1.44	15	131	4.74
20	18.85	S-17	175	1.07	1.36	*20	185	6.10
20	19.78	G-18½	175	1.15	1.42	*20	177	1.12
25	27.05	S-17	250	1.04	1.32	25	239	—7.58
25	28.24	G-18½	250	1.15	1.42	25	221	—11.45
50	49.30	S-19	500	0.98	1.29	50	506	1.42
50	48.50	G-30	500	1.00	1.22	50	515	3.09

MAZDA "C"

Nom. Watts	Present (Data Book) Computed Actual Watts	Bulb	Lumens	Watts per S. C. P.	Actual Watts	Proposed Lumens	Per cent Change Watts
			30-34 Volts				
40	36.6	PS-20	500	0.92		Discontinue	
50	50.7	PS-20	750	0.85	50	739	—1.38
75	62.0	PS-22	1,000	0.78	75	1,210	21.0
100	89.5	PS-25	1,500	0.75	*100	1,676	11.7
			60-65 Volts				
50	59.6	PS-20	750	1.00	50	629	—16.1
75	73.25	PS-22	1,000	0.95	75	993	2.39
100	102.7	PS-25	1,500	0.86	*100	1,461	—2.63

This proposed change has been submitted to a number of railroads in the form of a questionnaire in which connection eight replies have been received to date, all of which are favorable.

Your committee recommends the adoption of the proposed schedule by the association and also that all of the lamps except those marked * be shown in the standard schedule of lamps, the other sizes to be shown in the intermediate schedules.

2. *Change in Rating of Locomotive Cab Lamp.*—In conjunction with the headlight committee your committee recommends that the standard lamp for locomotive cab lamp service be a 15 watt, S-17 bulb, 33 volt tungsten B lamp, and to have such efficiency and method of filament mounting as experience deems most satisfactory for the service for which it is intended. In order to prevent confusing this lamp with the 15 watt, S-17 bulb train lighting lamp, it is recommended that the manufacturers place a small distinguishing label on these lamps with the words "loco cab light" or equivalent, this label to be no larger than labels now used for showing the rating. Inasmuch as the train lighting lamp is unsuited for service in cab lighting while the cab lighting lamp can be used for train lighting, the only objection being its considerably lower efficiency, consideration has been given to the question of using the cab lamp for both purposes. This matter was also covered in questionnaire, in which connection the majority of replies thus far received indicate that it is desirable to continue the use of the two different lamps, as many railroads are still using the 15 watt lamp for general illumination purposes. In view of the fact that many railroads are finding that more or less confusion exists due to the similarity of these two lamps, it has been thought advisable that a distinguishing label be placed on the cab lighting lamp.

3. *Baggage Car and Coach Illumination Tests.*—Your committee is preparing to conduct some tests in baggage car illumination, using center deck lighting with both the 50 watt tungsten B lamp and the new 50 watt tungsten C lamp. In view of the development of the new 50 watt tungsten C lamp it was felt that some test data of the results obtained with this lamp in day coach lighting, using one or two of the types of reflectors in general use, would be of considerable value to the railroads. The committee is, therefore, planning to obtain such data in conjunction with the baggage car tests.

4. *Standard Lamp Positions.*—While not instructed to investigate the subject, your committee has found that practically no standards exist with respect to the relative position of lamp bulb and reflector. As a consequence in changing from one type of reflector to another or in changing type of lamp bulb it is frequently necessary to change this lamp position in order to obtain the correct distribution of light. With many types of fixtures in use this is impossible or at least can be done only at considerable expense. Your committee, therefore, is making a study of the subject with a view to recommending certain positions to be adopted as standard, and that as far as practicable lighting fixtures for train lighting purposes should be so designed that these positions can be readily changed. The following positions have been tentatively selected, these representing the distance from the top edge of the reflector to the end contact of base of lamp:

1 11/16", 1⅛", ⅝", ⅜", 0"

With but slight changes in a few of the types of reflectors used in train lighting service these positions will permit obtaining correct distribution of light with the S-17, S-19, G-18½, G-30, PS-20 and PS-2 lamp bulbs which cover the train lighting range for all except the 100 watt tungsten C lamp, which would never be used with an open type of reflector. With further study of the subject it may be possible to reduce the number of positions still further. In connection with this subject the committee expects to present definite recommendations in its report at the fall convention and is presenting the matter at this time only for the purpose of obtaining discussion on the subject.

5. *Control of Lighting Circuits.*—Your committee was also instructed to investigate the subject of controlling the lighting circuits on postal and similar classes of cars that are frequently operated with doors locked; also the most satisfactory method for providing "night" illumination in coaches and similar classes of cars. This matter was also included in the questionnaire, but insufficient replies have as yet been received from which to submit definite recommendations.

Committee:—L. S. Billau (assistant electrical engineer B. & O.), chairman; A. H. Gerald (engineer assistant to chief electrician, Pullman Co.); J. L. Minick (assistant engineer, Pennsylvania Lines).

Discussion of the Illumination Report

During the discussion which followed the presentation of the report of the Committee on Illumination, the question arose of the advisability of eliminating the 60-volt lamp and using the 30-volt lamp exclusively. In this connection, Mr. Andreucetti, of the Chicago & North Western, pointed out very clearly that there were many roads that were extensive users of the 60-volt lamp and to do away with this type would work considerable hardship on these roads.

In view of the fact that cab lamps are practically of the same voltage as train lighting lamps, the question of such lamps being designed with the idea of interchangeability provoked considerable discussion. One manufacturer stated that his company was giving the subject of locomotive lamps special consideration in view of the special operating conditions to which they were subjected. His company, he stated, were striving to develop a lamp with a rigid filament that would withstand locomotive service, but this could only be done at the expense of efficiency, which in this case he thought was justifiable. In general it would seem that the cab lamps were not called upon to give the same quality of illumination as demanded of the train lighting lamps, and that, therefore, it would not be advisable to attempt to design a lamp that would be interchangeable.

R. S. M. A. Exhibit Breaks All Previous Records

List of Exhibitors and Representatives Whose Products Are of Interest to Electrical Men

THOSE who attended the 1919 conventions of the American Railroad Association in Atlantic City were tremendously impressed at that time with the magnitude of the exhibits on Young's Million Dollar Pier. Notwithstanding the fact that the exhibits last year were greater in number and occupied more space than any previous year, they were quite surpassed by those which attracted throngs of railroad men to Atlantic City last month.

Undoubtedly the experience of exhibitors last year is responsible for the fact that the demands for space this year far exceeded the capacity of the pier, and that it was not possible to anywhere near accommodate the large number of companies that made application for space. When the convention opened there were 359 exhibitors, with over 100,000 sq. ft. of exhibit space. The increase of almost 7,000 sq. ft. over last year was made possible by utilizing the balcony surrounding the ballroom. To do this it was necessary to remove the last two rows of seats and otherwise remodel the balcony; this resulted in an addition of 63 exhibit spaces, averaging 9 ft. by 11 ft., making a total of 6,706 sq. ft. In order that there might be no possibility of visitors overlooking these exhibits, arrangements were made to display the names of the companies prominently on the front of the balcony facing the ballroom.

Many of the exhibitors had great difficulty in getting their material to Atlantic City because of the railroad strike and the freight congestion. Too great credit cannot be given to the railroads for the splendid way in which they co-operated in expediting freight and express shipments containing exhibit material. The Pennsylvania Railroad in particular co-operated very closely with the Railway Supply Manufacturers' Association in this respect.

The table shows the remarkable rate at which the exhibit has grown in recent years. Those who predicted that the closing of the exhibit during the war years would seriously affect its future have been very badly mistaken; it seems rather to have added a renewed impetus to the growth of the big exhibition.

How the Exhibits Have Grown

Year	Exhibit space sq. ft.*	Number of exhibits
1910	71,019	...
1911	76,110	245
1912	83,507	262
1913	87,360	277
1914	82,218	266
1915	70,412	222
1916	76,643	258
1917 and 1918†	no exhibit	
1919	93,499	314
1920	100,061	359**

---

*Square feet of space actually paid for. Does not include free space to M. C. B. Committee.

**Number of exhibitors on Wednesday morning, June 9.

†No exhibit because of war.

Those exhibitors whose products are primarily of interest to electrical men are included in the following list:

List of Exhibitors

American Car & Foundry Company, New York, N. Y.—Two Berwick electric rivet heaters; two tank cars on the exhibition track. Represented by W. H. Woodin, Wm. M. Hager, G. W. Cornell, Horace Hager, Scott H. Blewett, C. S. Gawthrop, M. Buick, N. A. Doyle, W. F. Kingston, C. D. Eaton, J. H. Weisbrod, R. H. Davenport, M. C. Shands, S. W. Tuttle, W. A. Williams, H. C. Wick, C. A. Smith, L. T. Carroll, S. S. DeLano, S. A. Mallette, F. G. Wolff, H. C. Lunger, J. J. McBride, E. D. Campbell, Norman Litchfield, W. E. Hedgcock, M. J. Crispin, G. R. Scanland, E.S. Block, L. E. Hess, W. J. Harris, M. H. Connelly, O. H. Mellum, J. L. Onderdonk, A. Speirs, C. D. Terrell, F. H. B. Fowler, W. C. Dickerman, F. A. Stevenson, B. Wilson, D. M. Knox, J. M. Keller, T. A. Dooley, W. H. Sanford, John Ensign, L. M. Roe, Frank Faust, D. J. Whalen, F. H. Gibbs, A. E. Ostrander, F. C. Cheston, J. W. Sheffer, James S. Helt, A. G. Wood and W. M. Earle.

Atlantic Hand Brake Corporation, Buffalo, N. Y.—Worm gear hand brakes; combination hand and electric power brake. Represented by J. H. Weidenmiller and Chas. E. B. Smith.

Baker R. & L. Company, The, Cleveland, Ohio.—Industrial trucks and tractors. Represented by Nathanie Platt, M. A. Watterson, Wm. P. Kennedy and H. C Sherer.

Black & Decker Manufacturing Company, The, Baltimore, Md.—Portable electric drills, electric valv grinders and electric air compressors. Represented b G. R. Lundane, G. A. Dodge, M. E. Lilley and W C. Allen.

Buda-Ross Company, Chicago, Ill.—Sectional models of 1000 and G. W. electric headlight turbo generators. Represented by Mark A. Ross and Harry P. Bayley.

Chesapeake Iron Works, Baltimore, Md.—A standard Chesapeake electric traveling crane, 10 ton capacity; steel structure; machine work. Represented by F. S. Chavannes, C. H. Michel, J. W. Waters, C. S. Hill, Jr., F. L. Perry, C. M. O'Brien, Fred Brown, Jos. Hoff and Miss Shaw.

Chicago Pneumatic Tool Company, New York City, N. Y.—Boyer riveting and chipping hammers; rivet busters; stay-bolt riveters; pneumatic air drills, all sizes; air grinders; portable electric drills and grinders, all sizes, and accessories. Represented by H. A. Jackson, W. P. Pressinger, W. H. Callan, H. D. Megary, H. L. Dean, T. J. Hudson, C. B. Coates, H. G. Barbee, C. W. Cross, J. M. Stayman, T. G. Smallwood, A. M. Brown, Edw. Aplin, A.C. Andresen, Nelson D. Gatch, J. L. Crowley, E. K. Lynch.

Clipper Belt Lacer Company, Grand Rapids, Mich.—Demonstrating method of belt lacing, with clipper machine and hooks. Represented by C. P. Field.

Cutler-Hammer Manufacturing Company, The, Milwaukee, Wis.—A. C. and D. C. machine tool controller equipment. Represented by T. D. Montgomery, H. W. Stevens and R. H. MacGillivray.

Duntley Pneumatic Tool Company, Chicago, Ill.—Duntley riveting, scaling and chipping and calking hammers; rivet cutters; electric drills; air drills; rivet sets; all accessories for pneumatic tools. The new Duntley sleeve valve for riveting hammers. Represented by W. O. Duntley, W. M. Hankey, C. A. Duntley, E. A. Warnock, Geo. A. Barden and Robt. K. Crawford.

Edison Storage Battery Company, Orange, N. J.—Edison storage batteries for car lighting, signaling, multiple unit control and industrial trucks. Represented by Chas. E. Sholes, John Kelly, D. C. Wilson, A. M. Andersen and A. S. Knox.

Electric Arc Cutting & Welding Company, Newark, N. J.—A. C. arc weld and rivet cutting. Represented by O. D. Corbett, C. J. Holslag, C. S. Libby, H. W. Livermore and E. S. Fay.

Electric Controller & Manufacturing Co., Cleveland, Ohio.—EC&M automatic compensator, providing push button control of A. C. shop motors EC&M type ZB push button operated starting switch; automatic starters and machine tool controllers for direct current; Youngstown safety limit stop for crane duty; crane protective switchboard. Represented by R. G. Widdows, J. C. Snyder and H. K. Hardcastle.

Electric Service Supplies Company, Philadelphia, Pa.—"Golden Glow" locomotive headlights, sheet metal and cast iron types; keystone turbo generators; "golden glow" and "crystal" mirror glass reflectors; locomotive headlight switches; marker lights; classification lights; lamp guards; flood lights and searchlights. Represented by Chas. J. Mayer, A. H. Englund, J. W.

Porter, H. G. Lewis, T. M. Childs, J. R. McFarlin, L. A. Darling and J. G. Dellert.

Electric Storage Battery Company, The, Philadelphia, Pa.—Body hung, constant voltage, axle lighting equipment, complete with hand lever belt tension device; truck type generator; storage batteries; "Chloride Accumulator" giant jar assembly for car lighting; Exide and Ironclad Exide for signal and industrial truck service. Represented by J. Lester Woodbridge, T. L. Mount, F. G. Beetam, W. Van C. Brandt and H. E. Hunt.

Elwell-Parker Electric Company, The, New York, N. Y.—Electric storage battery industrial trucks. Represented by Lucian C. Brown, George W. Brown, F. B. Neely, F. B. Fink, C. C. Dietz, J. M. Brown, R. C. Howell, S. H. Ford and W. G. Lockwood.

Fairbanks, Morse & Company, Chicago, Ill.—Oil engine, direct-connected to electrical generator in operation; motor-driven centrifugal pump, direct-connected in operation; locomotive water crane; motor cars. Represented by F. M. Condit, E. J. Coverdale, E. C. Golladay, G. Howard, J. L. Jones, E. Lang, E. E. Pendray, Stephen Smith, A. A. Taylor, H. E. Vogel and C. H. Wilson.

General Electric Company, Schenectady, N. Y.—Automatic arc welding; hand arc welding; locomotive headlight sets; industrial control equipments; miscellaneous motors. Represented by J. G. Barry, W. J. Clark, C. C. Pierce, F. S. Hartman, John Roberts, R. E. Woolley, J. M. Hollister, L. S. Thurston, W. L. Merrill, John Eaton, C. K. West, C. Dorticos, W. T. Richmond and L. W. Shugg.

Gould Coupler Company, New York, N. Y.—Automatic slack adjusters; M. C. B. journal boxes; friction draft gears; couplers; electric car lighting; locomotive headlight equipment; storage batteries. Represented by Charles A. Gould, W. F. Richards, J. W. Reifsnyder, G. B. Young, C. E. Rood, W. H. Sauvage, P. H. Simpson, Charles A. Gould, 2d, G. R. Berger, W. F. Bouche and W. R. Shedd.

Hauck Manufacturing Company, Brooklyn, N. Y.—Oil burning equipment such as: Tire heaters, steel car repair burners, rivet forges, furnace burners, hand torches, thawers, sprayers. Steamers for sterilizing purposes; tool dressing furnace; brazing forge; melting furnace; low pressure burner; paint burner; locomotive fire kindler; steam testing burner. Represented by M. R. Jarvis, John D. Moore and F. E. Giersch.

Kerite Insulated Wire & Cable Company, Inc., The, New York, N. Y.—Reception booth. Represented by Azel Ames, P. W. Miller, J. W. Young, J. A. Benton, B. L. Winchell, Jr., and W. H. Fenley.

King Optical Company, Julius, New York, N. Y.—Safety goggles; face masks and shields; welding helmets. Represented by Fred W. King and Major J. N. Thomas.

Lakewood Engineering Company, The, Cleveland, Ohio.—One Lakewood 703 tier-lift truck; one Lakewood type 701 tractor; one Lakewood No. 810 trailer. Represented by Thos. T. Fauntleroy.

Lincoln Electric Company, The, Cleveland, Ohio.—Lincoln 200-300 ampere welder; Lincoln motors; Lincoln motor operating under water. Represented by Robt. E. Kinkead, D. C. Anderson and O. P. Lang.

Loco Light Company, The, Indianapolis, Ind.—One Loco light generator in operation; one Loco light generator, sectional view; headlight case. Represented by H. H. Tomlinson, C. Vossler, T. D. Kelly, B. Palmer Claiborne and Col. C. E. Bleyer.

Main Belting Company, Philadelphia, Pa.—Anaconda power transmission belting; M. B. C. car lighting belting; Leviathan conveyor belting; "Main" conveyor rollers; style "C" adjustable troughing roller; style "A" troughing roller; styles "R" and "S" return rollers. Represented by E. F. Hiller, H. B. Gramm and W. C. Schreiner.

Okonite Company, The, Passaic, N. J.—Okonite rubber covered wires and cables; varnished cambric wires and cables; splicing tape, Manson friction tape. Represented by J. L. Phillips, W. R. Van Steenburgh, J. W. Hackett, J. D. Underhill, C. A. Miller and F. J. White.

Page Steel & Wire Company, New York, N. Y.—Armco American ingot iron electrodes and welding wire; Ingot iron strand; ingot iron bond wires, telegraph wire, telephone wire, together with the latest developments of the Page company, namely:—Page Armco fence. Represented by W. T. Kyle, C. A. McCune, W. H. Beecker, Jr., E. J. Flood and C. L. Bennett.

Pyle-National Company, The, Chicago, Ill.—A model of the Young valve gear. A complete line of turbo-generators; electric headlight sets; suburban train lighting; headlight cases of all sizes; sheet steel and cast; locomotive cab lamps; back-up lamps; switches; connectors; focusing devices for lamps. Represented by R. C. Vilas, J. Will Johnson, Wm. Miller, A. N. Martin, C. P. McGinnis, T. P. McGinnis, R. L. McIntosh, O. W. Young, R. L. Kilker, W. T. Bretherton, G. E. Haas and W. Smith.

Railway Storage Battery Car Company, New York, N. Y.—One operating Edison battery car. Represented by L. Klopman, F. N. Koziell and C. A. Wipf.

Safety Car Heating and Lighting Company, New York, N. Y.—Electric and gas car lighting equipment; car lighting fixtures and reflectors; electric fans; oxy-Pintsch metal cutting equipment. Represented by W. L. Garland, J. H. Rodger, J. S. Henry, R. H. Harvey, S. I. Hopkins, A. B. Mills, H. D. Donnell, G. E. Scott, C. A. Pinyerd, J. L. Marsh, W. S. Wepf, H. K. Williams, H. W. Davies, A. P. Hagar, G. E. Hulse and L. Schepmoes.

Stone Franklin Company, New York, N. Y.—Complete single battery axle generator equipment; complete double battery axle generator equipment. Represented by R. G. Coburn, C. E. Walker, H. D. Rohman, J. L. Hays and W. L. Gray.

Sunbeam Electric Manufacturing Company, Evansville, Ind.—Type RE-3,500 watt, 32 volt locomotive headlight turbo-generator; pattern 1018 headlight; pattern 1412 headlight; pattern 1414 headlight; an assortment of reflectors, both glass and copper silver plated; also various accessories such as lamp stands, dimming devices. W. A. Carson, F. W. Edmunds, H. A. Varney, J. Henry Schroeder, L. B. Jones, W. T. Manogue and A. J. Leonard.

Transportation Engineering Corporation, New York, N. Y.—Electric storage battery trucks and tractors for freight stations, piers, shops and storehouses.

Trailers, for use with electric tractors or for hand operation; charging apparatus; switchboards; Wanamaker coated electrodes for electric arc welding; welding wire for electric and gas welding; welding accessories; electrode holders; face shields; masks; water stills. Represented by H. G. Thompson, F. V. McGinness, H. H. Smith, K. R. Hare, H. W. Stortz and W. F. Gunn.

U. S. Light & Heat Corporation, Niagara Falls, N. Y.—USL car lighting devices in operation; arc welding demonstration; car-lighting storage battery; Willys light and power plant with USL battery. Represented by H. A. Matthews, E. J. Blais, E. T. Sawyer, R. R. Desmond, W. L. Bliss, Geo. L. Kyle, Geo. P. Wray, J. F. Geiger, W. A. Turbayne, E. Bauger and O. R. Hildebrand.

Westinghouse Air Brake Company, Pittsburgh, Pa.—Universal passenger equipment demonstration rack of three cars and locomotive. Illuminated electric chart showing performance of UC passenger equipment with and without the electro pneumatic feature. Empty and load brake equipment demonstration rack. Westinghouse NA-1 friction draft gear complete; also a used gear taken out of service for test purposes after 25,000 miles' service on a large locomotive tender. Represented by A. L. Humphrey, W. S. Bartholomew, G. W. Wildin, C. C. Farmer, H. F. Woernley, E. A. Craig, J. B. Wright, F. H. Parke, R. W. Williams, C. R. Ellicott, F. H. Whitney, C. H. Beck, T. L. Burton, F. M. Nellis, C. J. Olmstead, A. K. Hohmyer, J. S. Y. Fralich, H. S. Clark, C. P. Cass, H. A. Wahlert, Robt. Burgess and T W. Newburn.

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.—Type 815 switch; type 809 reversing switch; type C controller class C-7440; types 815 and 816 switch; type A auto starter; type 816 switch; 500 watt 32 volt turbine generator; type F. B. controller; type S duplex controller; type HK crane motor; 175 arc welding outfit. Represented by W. H. Patterson, C. M. Harris, R. L. McLellan, C. C. Bawden, M. Clegg, R. F. Moon, R. J. Ross, E. M. Wise, D. R. Weidon, W. R. Stinemetz, C. W. Babcock, H. C. Mode, A. M. Jones, I. S. Forde, F. W. Carter, H. W. Beaumont, H. K. Smith, F. E. Wynne and C. C. Whitaker.

Willard Storage Battery Company, Cleveland, Ohio.—Two sectional cells TF-13 battery combination paste and plant type; one two-cell crate showing section TB-25 paste and TR-13 plante in hard rubber jars; one two-cell crate without paint or linings; miscellaneous parts. Represented by Louis Sears and E. L. Myers.

Wilson Welder & Metals Company, Brooklyn, N. Y.—Plastic arc welding materials. Represented by J. O. Smith, C. Hartford, P. H. Miller and S. A. Douglas.

In New Hampshire automobiles are required to limit speed to 10 miles an hour within 100 feet of railroad crossings; the State registrar of vehicles announces that the law is being rigidly enforced. The penalty is a fine of $50, or imprisonment for three months, or both fine and imprisonment; and also the revocation of the driver's license.

The First Train Run in the State of New York

The first train run in the State of New York has just been placed on exhibition in the east gallery of the Main Concourse of Grand Central Terminal, New York, by the New York Central Railroad Company. It consists of the "De Witt Clinton," the third locomotive that was built in America, its tender and three of the stage coach cars that accommodated passengers eighty-nine years ago.

The train rests on iron straps or bands which, nailed to beams, served as rails in its early day. In its entirety the train is not as long as the larger modern locomotives. It has been in storage for many years at the West Albany, N. Y., shops of the New York Central, was shipped aboard two flat cars and hauled through the city streets from the West Side freight yards to the Grand Central Terminal on motor trucks.

The origin and early trips of this little train, which was one of the wonders of its day, have been the subjects of many interesting stories. The engine named after the New York Governor, who was one of its first passengers, was built at the West Point foundry for the Mohawk & Hudson Railroad. Its first trial trip from Albany to Schenectady was made on August 3, 1831, when it covered the seventeen miles in one hour and forty-five minutes. The first trip with passengers was made August 9, 1831. On this occasion coal was used for fuel, but engine defects developed and the journey had to be finished with horses drawing the cars. After a number of changes had been made in the engine, the burning of coke was tried, but its use was not any more successful than with coal.

On September 24, 1831, after still more changes had been made in the engine, it was decided to substitute the "Robert Fulton," later called the "John Bull," as the locomotive that was to draw the first excursion train, operated on this day, between Albany and Schenectady. The "Robert Fulton," a heavier engine imported from England, failed to do its work and the "De Witt Clinton" was reinstated and functioned perfectly. The "De Witt Clinton" pulled the train into Schenectady to the music of bands and the roar of cannon, a big public celebration being held to mark the event. On this trip yellow pine wood was burned as engine fuel. Sparks from the smoke stack deluged the passengers, burning their clothes and making short work of the umbrellas and parasols with which those on the outside of the stage coaches tried to protect themselves. The return trip was made with five cars in 38 minutes, the last six miles being made in 14 minutes. At times on the initial trip a speed of 30 miles an hour was attained, which might have been considered as reckless traveling in those days.

The "De Witt Clinton" without its tender weighs 9,420 pounds; the tender weighs 5,340 and each of the three coaches weighs 3,420 pounds. The "De Witt Clinton" is 12 feet 10 inches long and its height, to the top of the steam dome, is 8 feet 5 inches. The tender is 10 feet 11 inches long. The coaches are small indeed, being only 14 feet long.

The modern New York Central Standard Pacific type of locomotive weighs 276,000 pounds, and its tender, when loaded, 158,000 pounds.

Echoes from Atlantic City

Recounting the Experience of I. Askum—Some of the People Whom He Met and What They Said

IT was the morning after the night before—not quite the same kind of a "morning after" that it might have been a year ago, to be sure, but nevertheless Askum didn't feel particularly full of "pep." Dancing into the small hours of the morning was all well enough, but a sleepless night which followed didn't tend to put him into a pleasant frame of mind. He had his breakfast as soon as the dining room was opened and started out for a walk down the boardwalk. As he strolled along the warm morning sun shone down upon him and a little fresh breeze blew in off the ocean. It was a beautiful morning and before long Askum was feeling more like himself again. He passed the Million Dollar Pier where the exhibits were housed, but it was still early and no one was about. Down the boardwalk he continued until he reached a little pavilion where almost unconsciously he turned in and sat down on one of the benches. He was quite alone. For a long time he sat watching the sunlight dancing on the restless waves and then slowly his head began to droop upon his breast. His straw hat fell off and rolled over into the corner, unnoticed. He was asleep.

When Askum awoke the boardwalk was once more crowded with people. The realization of what lay before him urged him to retrace his steps towards the exhibition pier, where he knew his task awaited him. He elbowed himself through the crowd in front of the pier and just as he was about to squeeze through the gate he came face to face with his old friend, Harry Meloy, who looks after things electrical, for the New York Central, lines west. Meloy looked as if a steam roller had passed over him, although, as you see, the artist has been kind. He was so thin that it wouldn't have been surprising if Askum had failed to recognize him altogether.

Harry Meloy

"I've been pretty sick for the last few months," said Meloy explaining his changed appearance, "I've taken enough medicine to swim in, and about all I've had to eat has been celery soup, so it's no wonder I'm thin."

"I suppose you were at the meeting of the electrical men at the Dennis yesterday?" asked Askum. "What did you think of it?"

"Well, those progress reports don't usually last very long, but in my opinion there's a lot of credit due to the electrical men who began the association years ago. The electrical man has been the goat for a long time, getting all the blame when things went wrong, but never any credit for good work. I'll be glad to see the old association join the A. R. A., for I believe it will give the men recognition which they have never had. The day is fast coming when the electrical men are going to get the credit that is due them."

Just then Ray Gallagher blew along and Askum got both of them to pose for a snapshot. A few minutes later he left Meloy and Gallagher and went along through the exhibit. He didn't get far, however, before he came across Frank Zimkowski, car lighting inspector on the New Haven, and a bunch of congenial companions.

Frank Zimkowski

"What do you think of the exhibit, Zim?" said Askum. "Fine, fine, biggest exhibit they ever had. I'm not much interested in headlights, but I see they've got a new a.c. set in there this year. That machine for drilling square holes is some machine, too. I'm having a good time, but my feet are so darn sore I can hardly walk."

"So you have moved up in the upper strata of society, have you?"

"How is that?" said Zim.

"Well, if I am mistaken, what you've got is a case of the fashionable malady known as boardwalk feet. Hope you recover, Zim, see you later."

Askum wandered on past the exhibition booths looking everywhere for familiar faces, but until he reached the open space by the seal tank he did not meet a soul he knew. Arriving at this point he became temporarily interested in watching two men whose sole ambition in life seemed to be to see how many shovels they could wreck. After watching for a while, his glance wandered from the shovel smashing pair into the next booth and—lo and behold—there was Simpson, the great promiser, looking like a million dollars, with a smile on his face a yard wide.

Askum went over and opened the conversation. "I see you got your old gang with you, Phil."

"Yes," spoke up Bouche, "it's the same gang that was here last year."

"That's right," said Askum, "I guess the picture I took last year will answer for this year, for I can't see as you've changed much, except that Phil is fatter."

"Oh, yes, we have, we're more prosperous looking," laughed Simpson, "and we ought to have a 1920 picture."

This is the Crowd "Zim" Was Traveling With. From Left to Right: P. J. Callahan (Boston & Maine), A. S. Knox (Edison Storage Battery Co.), W. F. Gunn (Transportation Engineering Corp.), L. M. Farley (Washington Terminal), O. R. Hildebrant (U. S. Light & Heat Corp.), H. J. McIntyre (Crouse-Hinds).

"All right, come on out here," and with that Askum lined them up in the sun and proceeded to spoil a perfectly good film.

"Say, Phil," he said, as they were once more back in the booth, "when are you going to get ready to tell the world about that apparatus I photographed for you last summer?"

"Don't get discouraged, Askum, we'll get around to it by and by. I meant to talk about it long ago, but somehow or other it didn't seem just right to say much."

The Gould Coupler Co.'s Representatives, From Left to Right: P. H. Simpson, G. R. Berger, W. F. Bouche, M. R. Shedd.

"Oh, yes, I see all right. It's the watchful waiting policy that was so popular (?) a while ago. Well, it's your funeral, not mine. So long, Phil, see you later."

Askum had gone but a short distance when he encountered McGary, chief electrician of the New York Central at New York. McGary was strolling about by himself, mentally digesting the new things among the exhibits that interested him.

"What do you think about the A. R. E. E. joining the A. R. A.?" was the question Askum put to him.

"I think it's a good idea," replied Mac and then, abruptly changing the subject, he continued, "Do you ever hear anything more about how Fred Fischer is getting along?"

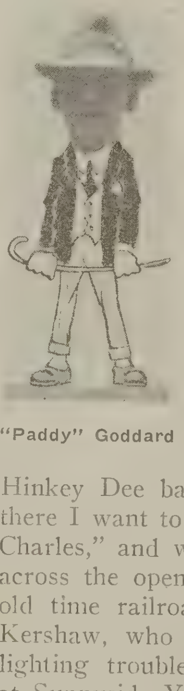
"The last I heard of him," said Askum, "he was doing fine."

"I am glad to hear it," said McGary.

A. McGary

Just then Askum's attention was arrested by the sound of a loud voice behind him, and turning about he discovered Paddy Goddard, a car lighting engineer from the Pennsylvania, in the act of making a few pointed remarks. Later Paddy explained. "I was bawling them out good and proper," he said. "I told them their darn equipment was no good."

"Well, Paddy, you know more about that than I do, but I can't help feeling that somebody in that concern is dead from the neck up. By the way, did you know the author of the Hinkey Dee stories was at the convention? There he is now talking to George Scott, I am going over to have a few words with him."

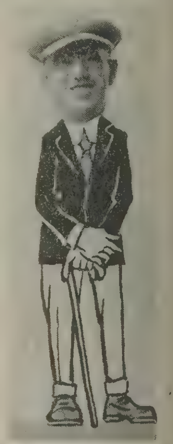


"Paddy" Goddard

Charles W. T. Stuart had just finished talking to Scott and was coming towards Askum who greeted him with outstretched hand. "How's Charles W. T?" inquired Askum, "I saw by the paper that you were spending a few days of your vacation here at the convention. How's Hinkey Dee these days? The car lighting boys sure do miss Hinkey."

"Hinkey Dee is laid up on the shelf," laughed Stuart, "and I can't say when I'll get him down and dust him off again, for I've a big job ahead in writing some other articles for those same car lighting men."

"Yes, I know you have, and they're going to be good, too, but I am sure the boys will be glad to welcome Hinkey Dee back again. There's another fellow over there I want to see before he gets away—see you later, Charles," and with that Askum hurried across the open space to greet another old time railroad acquaintance, Walter Kershaw, who used to look after car lighting troubles for the Pennsylvania at Sunnyside Yard, Long Island.



Chas. W. Stuart, the Originator of "Hinkey Dee"

"It's a long time since I've seen you, Kershaw. The last I heard, you were in the automobile business."

"Yes, I was, for a while. You see, after working nineteen years for the railroad and not getting to be president or general manager or anything, I thought it was about time to get out. I tried the automobile game, but there I got mixed up with a couple of undesirable citizens and gave it up along with a nice little piece of change. Finally I got into this truck and tractor business and everything is going fine."

"I'm glad to hear it, Walter, and let's hope it keeps on going good. There's George Wall and Al Prettyman over there—want to see them before they get away. I'll try and get around to see you again, Walter."

George and Al, both car lighting foremen, representing the Lackawanna and the New York Central, respectively, came steaming along behind two big perfectos. It was easy to see that they were really important people—that their opinions were really worth while. Askum knew them both from acquaintance dating back to the days of the old car lighting club in New York, in which both had been active members.

Walter Kershaw

"Well, look who's here!" said Wall as he caught sight of Askum.

"Yes, I'm here all right," admitted Askum, "and I'll say these exhibits are well worth looking at. Have you seen your old friend, Simpson, George? He's over there where they're banging those shovels to pieces. Same old grin an' everything. Sorry you didn't come along a little while ago—I would have introduced you to the author of the Hinkey Dee stories. You know he's going to write a series of articles for car lighting men; you fellows ought to be interested in that, George."

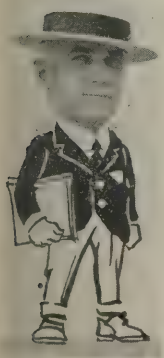
Geo. Wall

"Yes," broke in Prettyman, "they *ought* to be, but will they? Now if it was something about wages or working hours they wouldn't miss a word of it. In fact they'd be able to recite it word for word the day after they read it."

"Maybe you're partly right," said Askum, "but I don't think that applies to all, and I believe that some of them will get a lot of good out of that series."

"If you listen to this fellow," laughed George, "you'll get as optimistic as he is. Come on, Al, if we don't keep going we won't see half the things we came to see. So long, Askum."

Askum had nearly reached the convention hall on the pier before he met anyone else that he knew. Then just as he had about reached the conclusion that there were none of his acquaintances about, he discovered Charlie Sugg, electrical engineer for the Atlantic Coast Line, engaged in admiring some remarkable pieces of welding. Sugg didn't seem to remember Askum very well, and when the later asked him to pose for his picture he was inclined to be rather shy. "Somebody might see it," he remonstrated.


"Charlie" Sugg

"Ha! Ha!" laughed Askum, "you said something," but he finally got him to pose just the same.

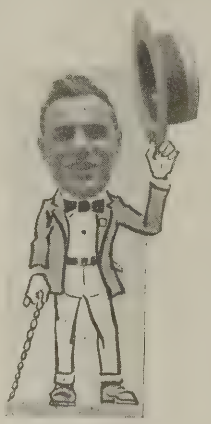
Charlie didn't take very kindly to Askum's remark when the latter said, "You work on the Seaboard Air Line, don't you?"

"Huh, no," retorted Sugg, "I work on a real railroad, the Atlantic Coast Line."

"I thought the Seaboard was quite a road."

"Oh! they buy a locomotive once in a while," returned Sugg, "but it's not in the class with the A. C. L."

Further out on the pier Askum was attracted by a loud noise that seemed to possess a familiar note, and sure enough just inside the little shed beyond the convention hall he came face to face with Holslag, of the Electric Arc Cutting and Welding Company, who was busily engaged in his favorite pastime of explaining why his welding machine was better than any other on the market.


C. J. Holslag

"That's some mit you've got there, Holslag," said Askum, after releasing his own fingers from the big, tough-skinned hand of the inventor.

"Got that way from hard work. By the way, Askum, here's a little book on welding that ought to be published in the *Railway Electrical Engineer,* words and music complete."

We might publish the words, but what about its music?

There was nothing to attract Askum further out on the pier and he retraced his steps back toward the main exhibits. The first person he saw on re-entering the door was "Bunny" Hare, of the Transportation Engineering corporation, who was busily engaged in demonstrating the advantages of a tractor. Bunny didn't have much to say, but one remark he did make made Askum wonder how much he knew about it from actual experience, was to the effect that "the most interesting time on the boardwalk is 4:30 in the morning." Not having been abroad at such an hour, Askum couldn't present any argument, but the tone of Bunny's statement led him to believe there might be something to it.

"Bunny" Hare

Passing along through the exhibition building, Askum came out into the open where he ran across Dick Sloan, chief electrician for the Pennsylvania at Pittsburgh, and Ed. Jansen, electrical engineer for the Illinois Central. Dick was explaining a wonderful scheme he had thought out for lighting freight cars while loading and unloading, but Ed didn't think much of it and proceeded to tell about one that was much superior.

"Ed" Jansen and "Dick" Sloan

"For the love of Mike! How long have you had that pipe, Sloan," inquired Askum, gazing in awe upon the caked and scarred tobacco incinerator.

"Only three years," replied Sloan, "and it's still good."

"You must have to watch it when you lay it down for fear it will walk away," laughed Askum.

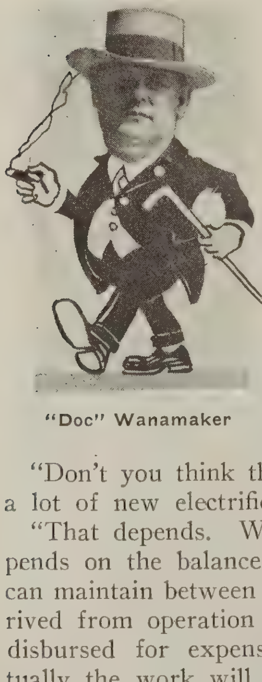
Then Jansen began telling about the plans for electrifying the Illinois Central. "Before they do very much electrification proper," he said, "they've got to practically rebuild all that part of Chicago that the railroads run through. It's going to be a mighty big job."

"Charlie" Quinn

Jansen's reference to electrification acted as a reminder to Askum that he wanted to see another electrical engineer, Charlie Quinn, of the Norfolk & Western. Quinn had a lot to do with electrification and might be able to say something of interest. It wasn't easy to find a particular person on the pier, but after a search of half an hour or so he located Quinn and opened up the subject of electrification.

"I've been told the B. & O. has been collecting data from various sources with the view of electrifying its line," said Askum.

"Yes," replied Quinn, "so I understand, in fact I helped to add to the data by giving some figures concerning the Norfolk & Western. However," he continued, "I don't believe a man can get very far in figuring out his own problem from some other fellow's viewpoint. Every electrification project presents different problems. The executive of the road contemplating this change wants to know what advantages would be derived from the application of electric motive power to his own road. He isn't particularly interested in other roads. Another thing," continued Quinn, "in planning electrification the thing to do is not to plan for today, but to lay your plans so that they will meet service requirements that will exist ten years from now."



"Doc" Wanamaker

"Don't you think the next few years is going to see a lot of new electrification work?" queried Askum.

"That depends. Whether there is much or little depends on the balance that the roads can maintain between the revenue derived from operation and the money disbursed for expenses. But eventually the work will be done and it wouldn't surprise me in the least if the next electrification on the Norfolk & Western saw 6,000-ton trains moved at 28 miles an hour. The day for heavy trains is coming," continued Quinn, "and while it may sound like a wild statement at present, I believe that some day trains as heavy as 14,000 tons will be handled as easily as the lighter trains are today."

H. K. Williams

The next man Askum met in his travels around the pier was his old friend "Doc" Wanamaker, electrical engineer of the C. R. I. & P. When it comes to electrical matters "Doc" is there with both feet, and even though he is tremendously interested in welding, he always has his ear to the ground for other electrical developments.

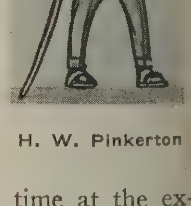
"I tell you, Askum," he said, "the electrical men on the railroads are too darn modest. They ought to get up on their hind legs and assert themselves. If they would they'd get somewhere. By the way," he continued, changing to his favorite theme and drawing a photograph from a big envelope, "here's a job of welding I want to show you. It's a welded expansion joint in a 14-in. air compressor pipe. You see it's on the outlet side of the compressor. It's been in service four years and has never shown a sign of cracking. Some welding, I'll say."

The Safety Car Heating & Lighting Company's Bunch. "This is the Way We Look When the Convention is About Over," said Williams. From Left to Right: Standing, H. W. Davies, A. P. Hagar, C. A. Pinyerd, A. B. Mills, H. K. Williams, A. V. Livingston; Seated, H. D. Donnell, S. I. Hopkins and Geo. E. Hulse.

Askum agreed that it certainly was a mighty good test of an arc welded joint. He wanted to get "Doc's" picture, but owing to the failing daylight the operation was postponed until the next morning when it was successfully performed with the result shown.

Kenneth Williams, of the Safety Car Heating & Lighting Company, was the next on the list and Askum got him to round up his gang of side kickers and took a snapshot of the bunch. If there's any advantage in numbers the Safety crowd sure had it, for they were well represented as may be seen.

"This is the way we look when the convention is nearly over," laughed Williams.



H. W. Pinkerton

A little later on Askum met Pinkerton, assistant engineer on the New York Central, who was just arriving. "Just blew in ten minutes ago," he said. "I've only got one day to spend here and I am going to spend all my time at the exhibits. I wish I had more time though," he laughed, "for I've seen some attractions that make me wish I had another day."

After leaving Pinkerton, Askum wandered down along the eastern side of the exhibition pier. The day was pretty well spent. Many of the railroad men had already left for home and all about the convention were unmistakable signs that the affair was drawing to a close. "I ought to get a picture of Rohman and his outfit," thought Askum, recalling the interesting photograph he had taken a year ago and he directed his steps towards the place where he expected to find them. Sure enough on arriving at the booth of the Stone-Franklin Company, Askum found Hays, Rohman and Walker busily engaged in waiting for a chance to explain their car lighting equipment. Since it had been explained to Askum on various occasions he was not eligible as a victim, but they were glad to see him just the same and after a few introductory remarks he managed to get them outside to pose for a snapshot. In order to let the folks know who they were, Rohman lugged along an armature.

A Stone-Franklin Trio; From Left to Right, J. L. Hays, C. E. Walker, H. D. Rohman.

"Well," said Rohman after they were once more back in the booth, "the convention is about over again, but it has been the most productive of tangible results of any I've ever attended. It is not often that orders for car lighting equipment are taken at the convention."

Askum recalled having heard practically the same thing from the other supply men earlier in the day, and he felt he could quite agree with them. As he walked slowly back to the hotel a smile stole over his face as he thought of the many interviews he had had and of the snapshots he had taken. "Won't they be surprised," he thought.

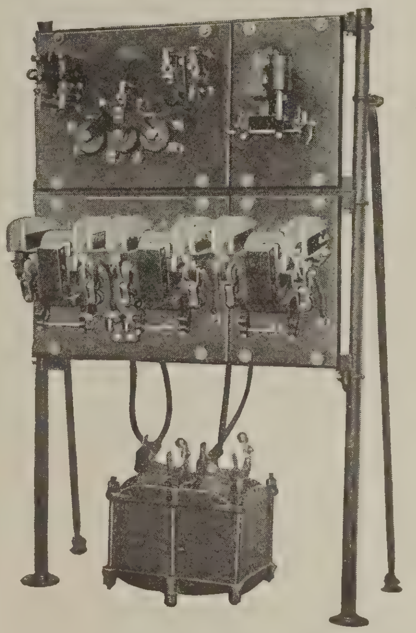
• • • •

Automatic Starter for Squirrel Cage Motors

The control panel shown in the illustration has been developed by The Cutler-Hammer Mfg. Co., of Milwaukee, Wis., for the automatic starting of polyphase squirrel cage induction motors driving loads of great inertia, such as mine fans, which require several minutes to come up to speed. This controller is essentially an automatic starter of the auto-transformer type, and consists of three double pole magnetic contactors, two auto-transformers, a current limit relay and a time limit relay, with the necessary auxiliary magnetic switches. The switch equipment is mounted on slate panels carried on a floor type frame, while the transformers are mounted separately.

One contactor acts as a main line switch, and the other two connect the motor to the starting taps of the transformers and to the line respectively. The interval between the closing of the second and third contactors, which is the time given the motor to come up to speed, is governed by the series current relay and the dash-pot relay, either of which is externally adjustable for current or time values.

The use of both relays is made necessary for the following reasons: Time relays are generally unreliable when set to operate at a longer time than 10 or 15 seconds, therefore they cannot be used by themselves under the above conditions of starting. Series current relays are reliable over a wide range of current values, but if set to release at the low current values obtained when starting under normal conditions they will usually fail to function should the load be increased even slightly or the line voltage fall below normal. On the other hand, if set for higher values the series relay will connect the motor to the line before it has reached speed under normal conditions of load and line pressure, thus drawing undesirable peak currents from the line. By combining both types of relays, the current relay is made to function first, it being set for a high enough current value that its operation will be assured under practically all conditions of load and line voltage, and the dash-pot relay gives the proper time interval after the former has functioned.


New Automatic Motor Starter

Control of this automatic starter may be by push button stations, snap switches, or other contact making device, from any remote point. Low voltage protection is provided with 3-wire control by push buttons, and low voltage release with 2-wire control.

The adjustable feature of both relays makes this starter applicable to almost all operating conditions, regardless of the variation of the line potential and the load.

Magnetic Type Direct Current Controllers

Descriptions and Diagrams of Apparatus for Operating Motors at Varying Speeds in Either Direction

By Gordon Fox

A MAGNETIC controller comprises an assembly of unit contactors and relays so inter-related as to perform the required control functions. The requirements are extremely varied. As a result there are innumerable designs or assemblies differing in greater or lesser degrees. It would be impossible to describe, in limited space, any considerable number of control designs. We will therefore select for discussion a few of the simpler and more typical starters and controllers, representing the underlying principles as applied by different builders.

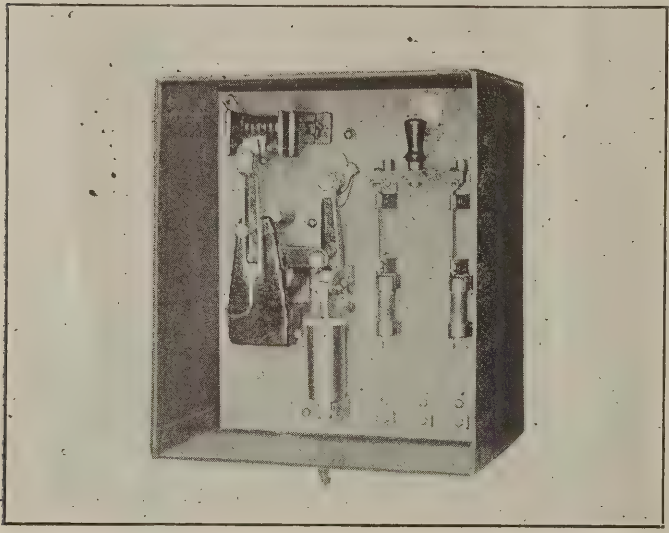


Fig. 1—Simple Time Element Starter for Small Direct Current Motor

Time Element Starter

A simple magnetic starter, based upon time element acceleration, is shown in Fig. 1, and the connections given in Fig. 2.

The units required for this starter are as follows: a knife switch to disconnect motor and control from the line; fuses for overload protection, a shunt line contactor *1* to open or close the main motor circuit; a time element accelerating contactor to cut out the accelerating resistance. Control is by a two-point push button with "start" and "stop" functions.

When the "start" button is depressed the line contactor closes, connecting the motor across the line in series with the accelerating resistance. Closure of the line contactor *1* depresses a spring tending to close contacts *11*. The closure of these contacts is delayed by an oil dash pot, allowing the motor time to accelerate before the starting resistance is cut out. The "stop" button causes both *1* and *11* contacts to open by opening the circuit of the line contactor coil.

Starter for Adjustable Speed Motor

A magnetic starter for an adjustable speed motor is shown in Fig. 3. The connections are given in Fig. 4. The contactor units which make up this starter are as follows: A knife switch is supplied to disconnect the motor and control circuits and to provide overload protection. A shunt line contactor *1* serves to open and close the motor circuit. Two accelerating contactors *11* and *12*, operated on armature countervoltage, serve to short circuit the accelerating resistance. Control is by a "start" and "stop" push button. The action of the starter may be described as follows:

Off Position.—The main motor circuit is open at contactor *1*. Motor and control circuits have potential unless the line knife switch is opened.

Operation.—Push "start" button. This establishes a control circuit from positive source through knife switch and fuse, through line contactor coil *1*, through the normally closed "stop" button, through the normally open "start" button, through fuse and knife switch to negative. This closes line contactor *1* which, in turn, closes its auxiliary contacts. The closing of these contacts establishes a holding circuit independent of the "start" push button, so that when this button is released, contactor *1* remains closed.

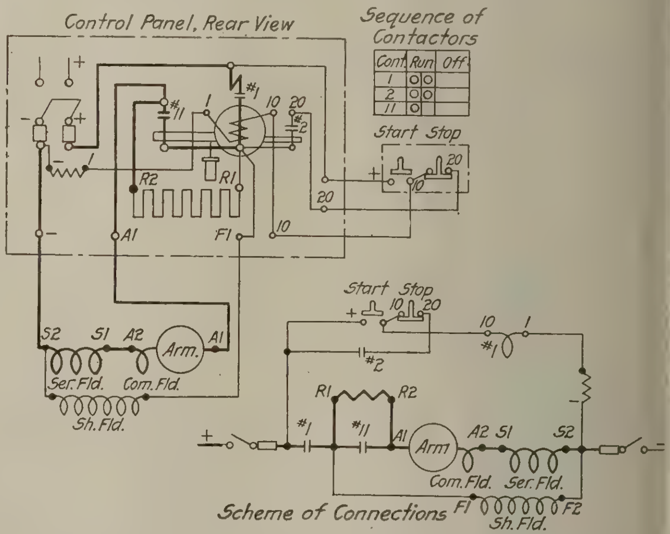


Fig. 2—Diagram of Connections—Time Element Starter

The closing of line contactor *1* completes the main circuit from positive source through the knife switch and fuse, through contactor *1*, through the field relay series coil, through the starting resistance, through the motor armature and series fields, and through the switch to negative line. The motor now starts.

Upon the first rush of current through the circuit, the field relay closes, shunting the field rheostat and providing full shunt field current. As the accelerating current falls off, the field relay may open. This introduces the motor field rheostat resistance. Weakening the shunt field tends to speed up the motor. This increases the load and closes the field relay. This relay will likely flutter a few times while the motor is accelerating, after which it will remain definitely open unless a heavy load comes on the motor, when it will close and tend to slow down the motor, which, in most instances, will relieve the load.

The closing coil of accelerating contactor *11* is connected across the armature and a portion of the resistance. When the motor is first started there is little voltage across the armature, hence no tendency for this contactor to close. As the motor speeds up, the countervoltage increases. When the countervoltage has attained a value of perhaps 150 volts, the closing coil of contactor *11* is sufficiently energized to close that contactor and cut out the step *R1-R2* of accelerating resistance.

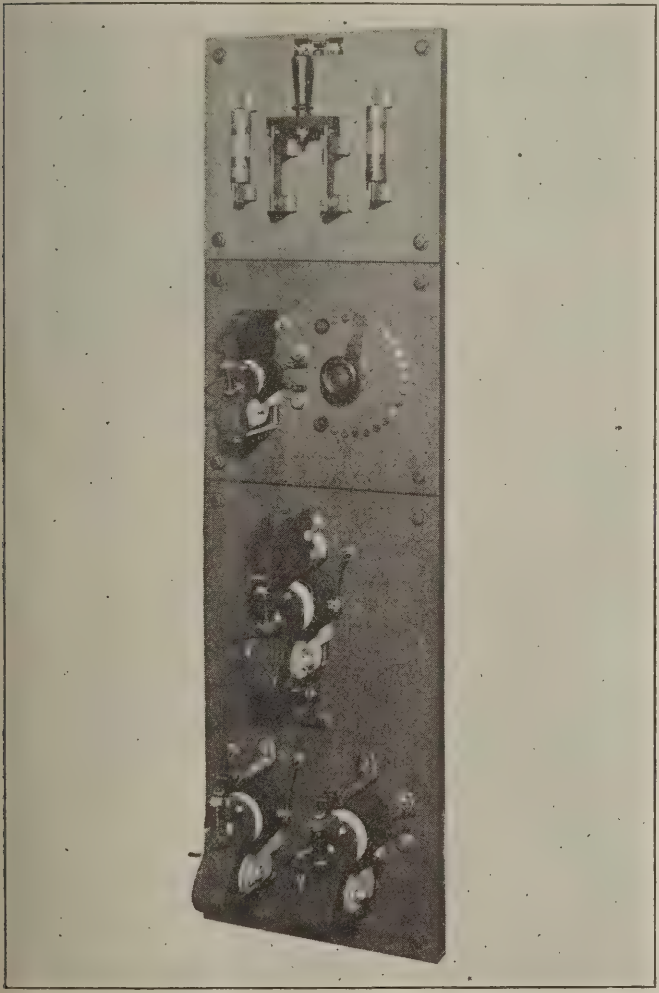


Fig. 3—Starter for Adjustable Speed Motor

As the armature accelerates further the countervoltage across the shunt closing coil of accelerating contactor *12* increases to a point where this contactor will close. This short circuits the rest of the accelerating resistance. The motor now attains full speed corresponding to the field rheostat position. It will be noted that the coils of accelerating contactors *11* and *12* are now subject to full line voltage. They therefore close positively and remain closed.

Stop.—When the "stop" button is depressed the main control circuit is opened, causing line contactor *1* to open the main motor circuit.

Overload Protection.—Overload protection is provided through the use of fuses in the main circuit. There is no further protection against field failure.

No Voltage Protection.—Failure of line voltage causes contactor *1* to drop open, its closing coil being deenergized. It is then necessary to depress the "start" button to start the motor.

Reversing Controller with Series Accelerating Contactors

A simple reversing controller with plugging and accelerating currents, limited by series lockout contactors, is illustrated in Fig. 5. The connections are shown in Fig. 6.

The units which comprise this controller are as follows. A knife switch is supplied to disconnect the motor and main controller circuits from the line. With this arrangement it is possible to try out the controller with the main knife switch open and the motor at rest.

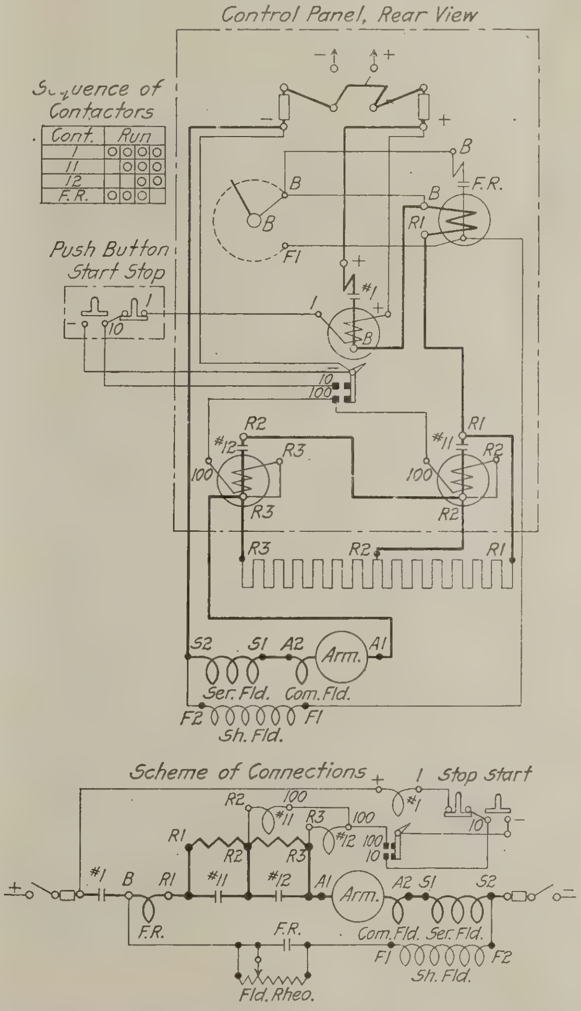


Fig. 4—Diagram of Connections—Starter for Adjustable Speed Motor

Four shunt contactors *1*, *2*, *3* and *4* are supplied to reverse the armature connections. A shunt line contactor *5* is supplied to disconnect the motor from the negative line. Three series lockout contactors *11*, *12* and *13* serve to cut out the accelerating resistance. A two-coil overload relay, instantaneous or time trip, instantaneous reset, is supplied for protection, the coils being connected in the main circuit next to the positive and negative lines. The presence of this relay, in conjunction with the line and directional contactors at the ends of the motor circuit, protects against a heavy flow of current into the motor from either line due to a ground. A voltage relay is supplied to afford no voltage protection. Control is by a simple reversing master switch. The action of the controller may be outlined as follows:

Off Position.—The master establishes a circuit from positive line through coil of voltage relay to negative line, causing the voltage relay to close. A circuit is then established from positive line, through the voltage relay contact and coil and overload relay to negative line. This circuit does not include the master. The voltage relay therefore remains closed when the master leaves the off position. The voltage relay opens either upon failure of voltage or when the overload relay opens. It is then necessary to return the master to off position to reset the voltage relay. Until this is done the motor will not start, as the main contactors cannot close unless the voltage relay is closed.

First Step Forward.—The master completes a connection from positive to shunt coils of directional contactors 1 and 3 and line contactors 5. This control circuit passes through the voltage relay contact, through master, thence through the shunt coils of contactors 1, 3 and 5 in series, thence to negative. The main circuit is now closed from positive line, through overload relay coil, through directional contactors 1 and 3 and armature, through series field, through coil of series lockout contactor 11, through the entire accelerating resistance, through line contactor 5, through overload relay coil to negative.

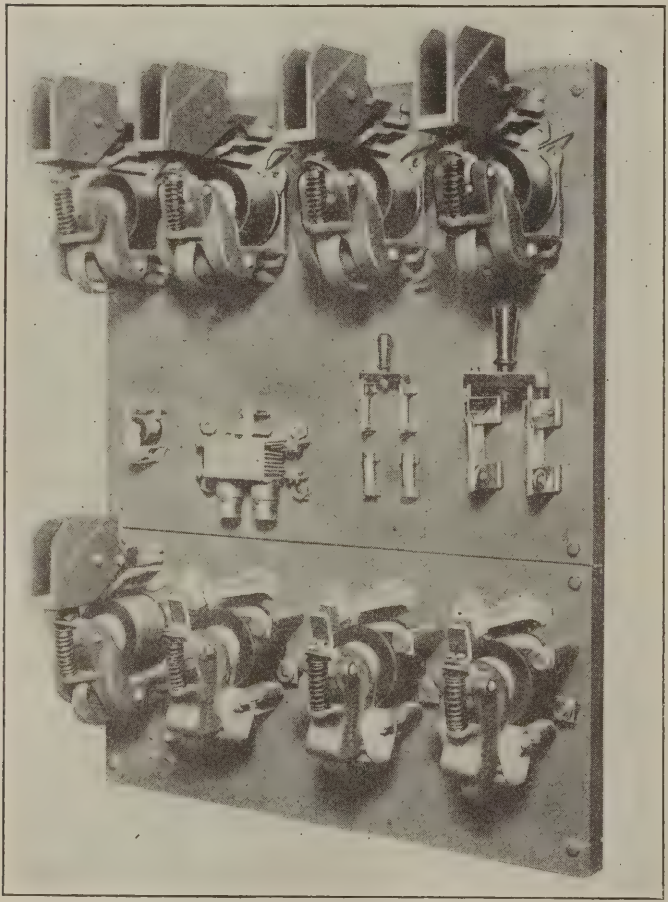


Fig. 5—Reversing Controller With Series Accelerating Contactors

Second Step Forward.—Master and all shunt coils remain as on first point. The current through the series lockout coil 11 drops to such a value as to permit accelerating contactor 11 to close, shunting out resistance *R1-R2*. The main circuit is now from positive through overload relay coil, armature and directional contactors, series field, through accelerating coil and contactor 11, through the series lockout coil 12, through a part of the resistance, namely *R2-R4*, through line contactor 5 and overload relay coil to negative line.

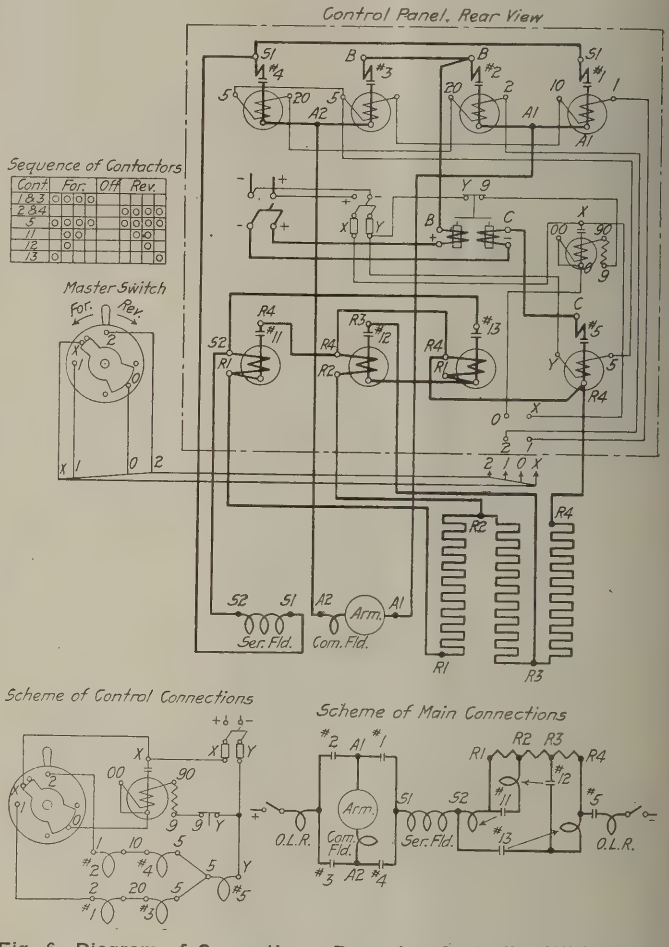


Fig. 6—Diagram of Connections—Reversing Controller With Series Accelerating Contactors

Third Step Forward.—This differs from the first and second steps only in the amount of resistance in circuit. The current through series lockout coil 12 drops, allowing accelerating contactor 12 to close, shunting out resistance *R3-R4* and leaving only resistance *R2-R3* in circuit.

Fourth Step Forward.—The current in series lockout coil 13, now in circuit, drops, allowing contactor 13 to close. This shunts the entire resistance and the series lockout coils 11 and 12, allowing these contactors to open.

Reverse Direction.—Same as forward except that directional contactors 2 and 4 are operated, through point 2 on the master, instead of directional contactors 1 and 3, affecting reversal of current through the armature.

Plugging.—This control may be adapted for plugging service by use of sufficient resistance *R1* to *R4* to limit the plugging current peaks. Series lockout contactor coils and settings should then be adjusted so that contactor *11* holds out for plugging but closes quickly when starting from rest. Resistance *R1* and *R2* then serves as extra resistance to limit plugging peaks only. Resistance *R2-R4* is normal starting resistance.

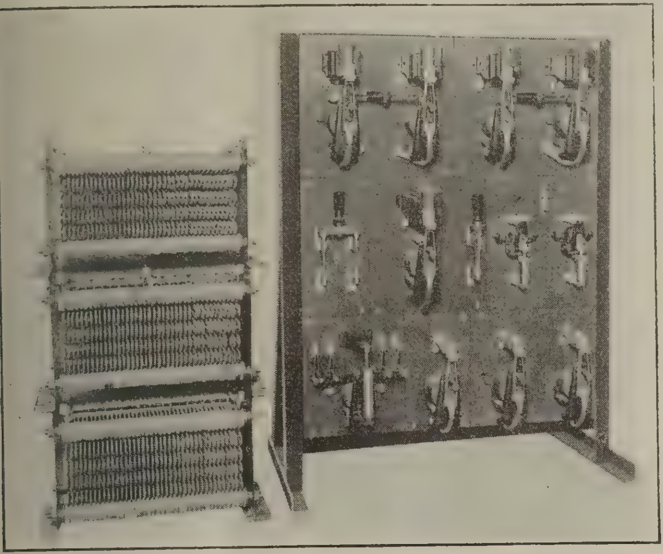


Fig. 7—Reversing Controller With Time Element Acceleration

Overload Trip.—Excess current through either or both overload relay coils, due to a ground; or to overload on the motor, will break the control circuit at the overload relay, de-energizing the voltage relay coil, as described above.

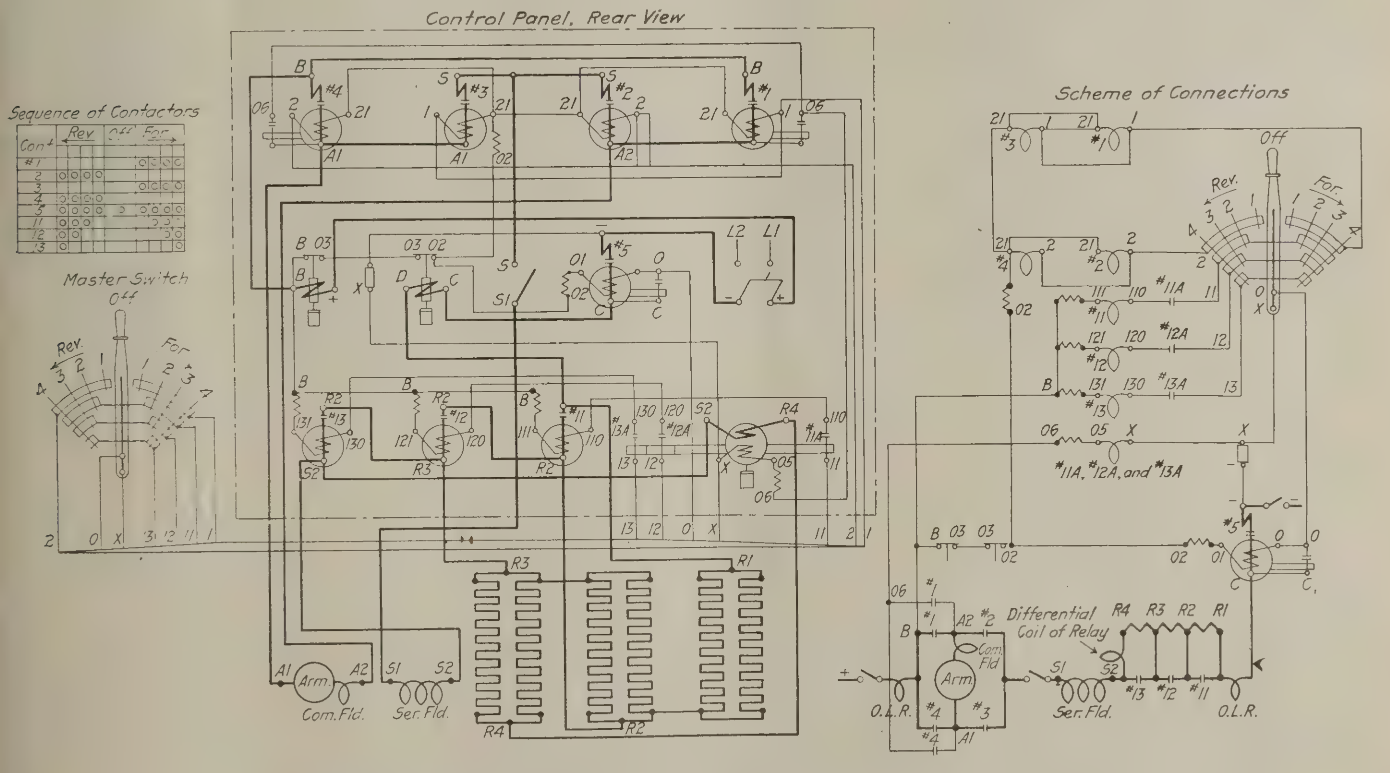


Fig. 8—Diagram of Connections—Reversing Controller With Time Element Acceleration

General Comment.—It is to be noted that accelerating contactor *13* is held closed by the load current through its series closing coil. If the load falls to a low value or becomes overhauling this contactor will open, reinserting the accelerating resistance. This may or may not be a serious objection.

It may be further noted that no speed control is possible where series accelerating contactors are used. The master merely starts and stops the motor. Acceleration is entirely automatic and independent of the operator.

Reversing Controller with Time Element Acceleration

A simple reversing controller with speed control and with plugging and accelerating currents, limited by a time element relay, is illustrated in Fig. 7, the connections being shown in Fig. 8. The units comprising this controller are: a two-pole knife switch to disconnect motor and control from the line; four shunt contactors, *1*, *2*, *3* and *4*, interlocked mechanically, for reversing the armature connections; a circuit breaker contactor *5*, for disconnecting motor and control from the negative line; three shunt accelerating contactors, *11*, *12* and *13*, for cutting out starting and plugging resistance; a time element accelerating relay; a single pole knife switch to permit testing the controller with the motor inoperative; two inverse time trip, instantaneous reset overload relays, and a suitable master switch. The action of the controller may be outlined as follows:

Off Position.—The master switch completes a circuit through the closing coil of circuit breaker contactor *5*, causing this contactor to close. An auxiliary holding-in contact on *5* contactor then serves to retain this contactor closed when the master leaves the off position. If contactor *5* is opened during operation by action of the overload relays, it becomes necessary to return the master switch to off position to again close this contactor.

First Step Forward.—The master switch completes a circuit through the closing coils of directional contactors *1* and *3*. This circuit passes the overload relays so that the tripping of the overload relays in addition to opening the *5* contactor also opens the directional contactors. When the main circuit is closed through contactors *1* and *3*, the motor starts.

When contactor *1* closes it also closes an auxiliary contact which completes a circuit through the shunt coil of the accelerating relay. This relay is also acted upon by its series coil which is included in the motor circuit and which opposes the action of the shunt coil. Unless the motor current is very heavy the relay will close, compressing a spring tending to close the relay contacts *11a, 12a* and *13a*. The closure of these contacts is delayed by an oil dash pot allowing the motor time to accelerate before the starting resistance is cut out.

Second Step Forward.—The master switch completes a circuit through the closing coil of accelerating contactor *11* so that this contactor will close when accelerating relay contact *11a* is closed. A portion of the accelerating resistance is short circuited by contactor *11*.

Third Step Forward.—The master switch completes a circuit through the closing coil of accelerating contactor *12*, causing it to function similarly to contactor *11*, reducing the accelerating resistance.

Fourth Step Forward.—The master switch completes a circuit through the closing coil of accelerating contactor *13*, causing it to function similarly to contactors *11* and *12*, cutting out all accelerating resistance.

Reverse Direction.—Same as forward except that directional contactors *2* and *4* close instead of contactors *1* and *3*, effecting reversed flow of current through the armature.

Plugging.—This control may be adopted for plugging service by insertion of sufficient plugging resistance at *R1-R2* to act in conjunction with accelerating resistance *R2-R4*, to limit the current peak. The starting from rest may be slightly delayed with this arrangement. In this connection it may be noted that the dash pot on the accelerating relay does not delay the opening of that relay. This obviates the danger of plugging with this relay partially closed, hence with accelerating resistance partially cut out.

Overload Trip.—Excess current through either or both overload relays, due to a short, overload or ground, will open the circuit of circuit breaker contactor *5* and the directional contactors, causing them to open. The auxiliary contacts on the directional contactors are thus opened, causing the accelerating relay to open.

No Voltage Protection.—In case of failure of voltage with the master in other than the off position contactor *5* falls open. It is then necesary to return the master to off position to reset this contactor.

Acceleration and Speed Control.—If the master be thrown quickly to last point the acceleration is governed by the time element of the dash pot modified by the action of the series coil in delaying the action of the shunt coil of the accelerating relay. Contacts *10a, 11a* and *12a*, are arranged angularly so that they close in sequence at intervals. These intervals are subject to adjustment.

If the master be thrown to the first point and later advanced to further points, the accelerating relay may have already closed so that the accelerating contactors are closed, as rapidly as the master is advanced. Ordinarily this does not cause a high rush of current as the greatest peaks usually occur during the initial acceleration.

The control may be modified by causing the shunt closing coil of the accelerating relay to be energized on the second rather than the first point. Acceleration beyond the first point is then delayed, the relay functioning when the second point is reached.

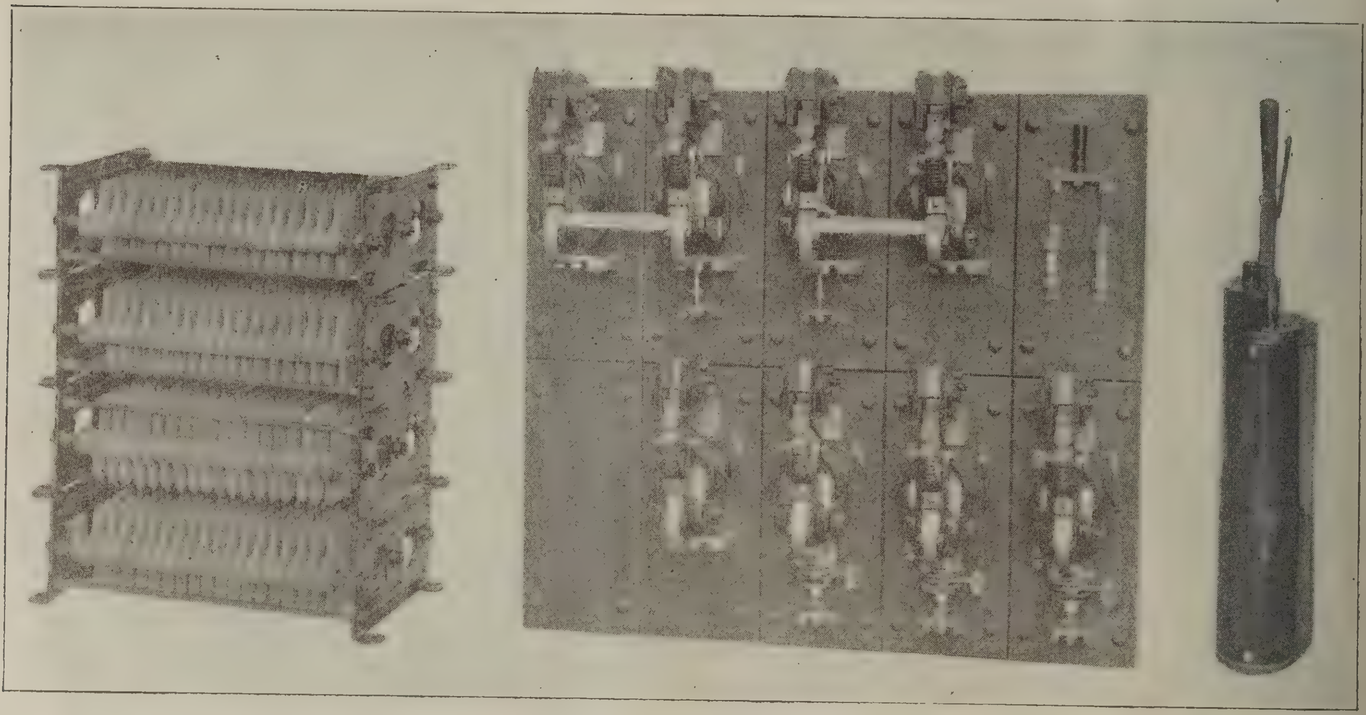


Fig. 9—Reversing Control With Series Accelerating Relays

Reversing Controller with Series Accelerating Relays

A reversing controller with acceleration limited by series relays and giving two points of speed control is illustrated in Fig. 9. A diagram of a similar controller is shown in Fig. 10.

The controller shown in the diagram comprises a main line switch and a fused control switch for disconnecting the motor and control circuits. Four shunt contactors *1*, *2*, *3* and *4* are directional contactors. These are mechanically interlocked. Shunt contactor *5* is a circuit breaker switch. There are three shunt accelerating contactors, *11*, *12* and *13*. Two overload relays are supplied.

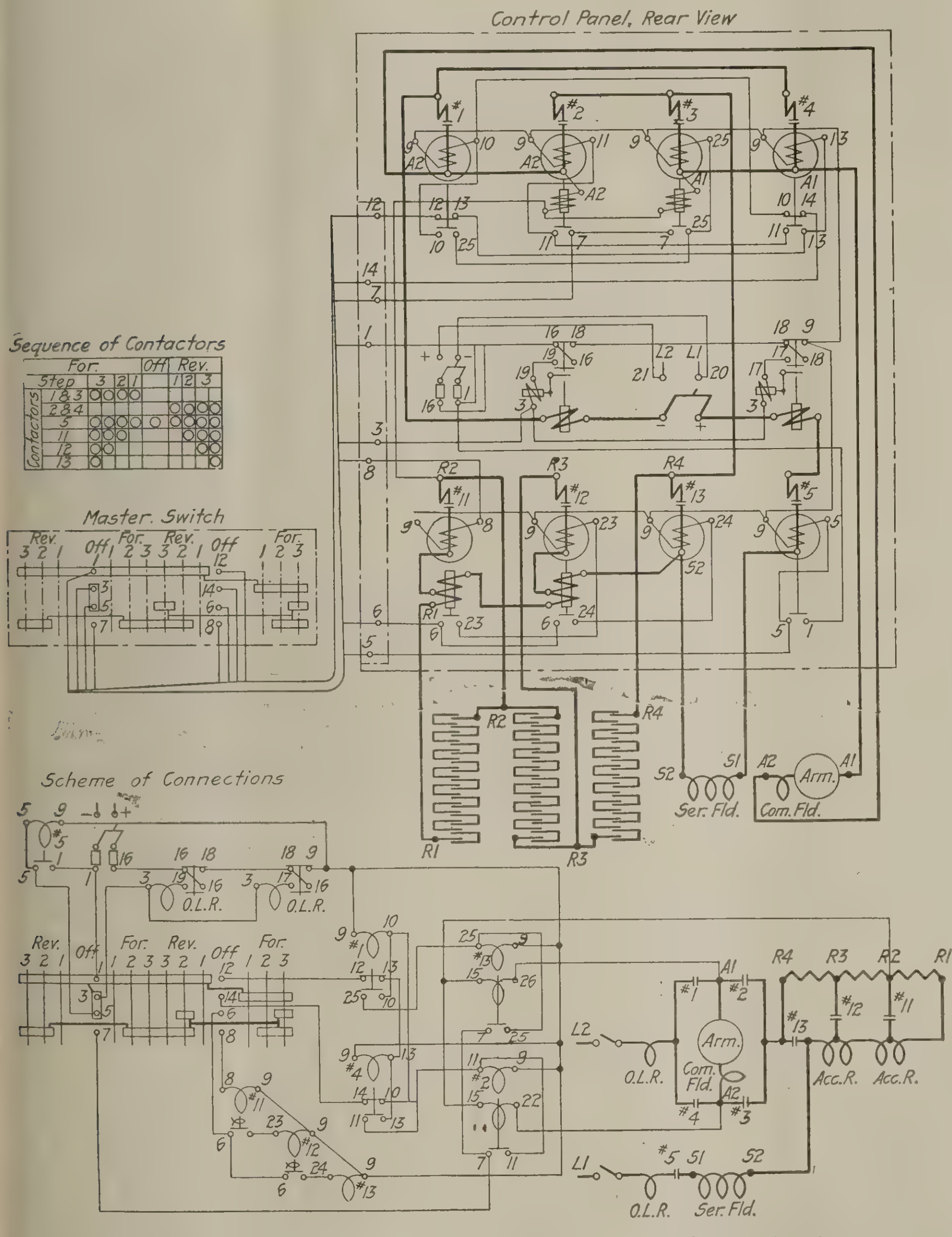


Fig. 10—Diagram of Connections—Reversing Controller With Series Accelerating Relays

The master is of the drum type with two rows of fingers. The action is as follows:

Off Position.—A circuit is completed in the master switch energizing the closing coil of *5* contactor. When this contactor closes, its auxiliary contact completes a holding-in circuit independent of the master. The reset coils of the overload relays are also energized with the master in the off position.

First Point Forward.—The closing coil circuit for *1* contactor passes through an auxiliary contact of *4* contactor. This auxiliary contact is closed when *4* contactor is open. In this manner an electrical interlock is provided for the directional contactors in addition to the mechanical interlocks. With the master on the first point forward the closing coil circuit for *1* contactor is completed. When this contactor closes it completes the circuit for the closing coil of *3* contactor. The closure of these two contactors (*5* remaining closed) starts the motor with full accelerating resistance in circuit.

Second Point Forward.—The shunt relay connected with contactor *3* is connected across the accelerating resistance *R2-R4*. In starting the motor from rest the voltage drop across this resistance is insufficient to hold up this relay, so it drops. This completes a circuit from negative source through the auxiliary contacts of contactors *4*, *1* and *3* to the lower section of the drum. When the master moves to second point, a circuit is completed from the lower section of the drum through the closing coil of *11* accelerating contactor. The closure of this contactor steps out some of the accelerating resistance.

Third Point Forward.—With the master on this point the circuit for the closing coil of *12* contactor is completed at the master and through the contacts of the series relay connected with *11* contactor. As soon as the motor current falls sufficiently for this relay to drop, *12* contactor will close.

The closing circuit for *13* accelerating contactor is taken from the same point on the master and passes through the contacts of the series relay connected with contactor *12*. As soon as the motor current permits this relay to drop, *13* contactor closes, cutting out all accelerating resistance.

The purpose of the two part series coils on the accelerating relays is to give these relays an excess power to hold up the plunger except at the time the relay is to drop at its set value. At this time only a portion of the series coil is in circuit.

Reverse.—Operation in the reverse direction is identical except that directional contactors *4* and *2* close instead of *1* and *3*, reversing the current flow through the armature.

Plugging.—The resistance is so designed that *R2-R4* is sufficient to limit the current to a safe value in starting the motor from rest. Resistance *R1-R2* is additional resistance to absorb the additional voltage in plugging due to the line voltage and counter-voltage being momentarily additive. To protect the motor on plugging the shunt relays are provided in connection with contactors *2* and *3*. These relays shunted across the resistance *R2-R4* do not have sufficient voltage impressed to remain open when the motor is started from rest. When the motor is plugged, however, the voltage impressed on these coils is higher so that the relays hold up until the plugging voltage falls off.

Overload Protection.—The two overload relays adjacent to the positive and negative lines, fully protect the motor. This type of relay is held closed by a catch. This catch is released by a plunger in case of overload. The relay then remains open by gravity until closed by the reset magnet which is energized only at the off position of the master. The overload relays open the control circuits for all contactors.

No Voltage Protection.—Upon failure of voltage, all contactors drop open. Circuit breaker contactor *5* will then remain open until the master is returned to the off position.

The curves in Fig. 11 set forth the speeds which will result with varied loads and with different amounts of accelerating resistance in circuit. The curves refer to a control arranged for plugging duty. When the motor is plugged the full resistance *R1-R4* is in circuit. If the motor be plugged when running at 500 rpm (negative speed) a current peak of about 230 amperes will result, as shown by the marked point on Curve A. As the motor decelerates this current will fall off, following Curve A. When the motor comes nearly to rest the closure of contactor *11* reduces the resistance in circuit to *R2-R4*. A momentary peak of about 200 amperes results as indicated on Curve B. If the master is held on second point the motor will now have a characteristic as shown by Curve B and will assume a speed corresponding to its load as indicated by some point on Curve B. If the master be moved to third point the accelerating resistance will be reduced to *R3-R4* by closure of contactor *12*. If the motor happens to be rotating at 300 rpm when contactor *12* closes (indicated on Curve B) a current peak of about 160 amperes will be taken when the resistance is reduced. The motor will then accelerate to some such point as indicated on Curve C, when contactor *13* will close. A peak of about 190 amperes will now be taken, as indicated on Curve D. The motor will continue to accelerate until it reaches a speed normal to its working load, as indicated by some point on Curve D. For all positions the torques corresponding to varied current values are shown by Curve E.

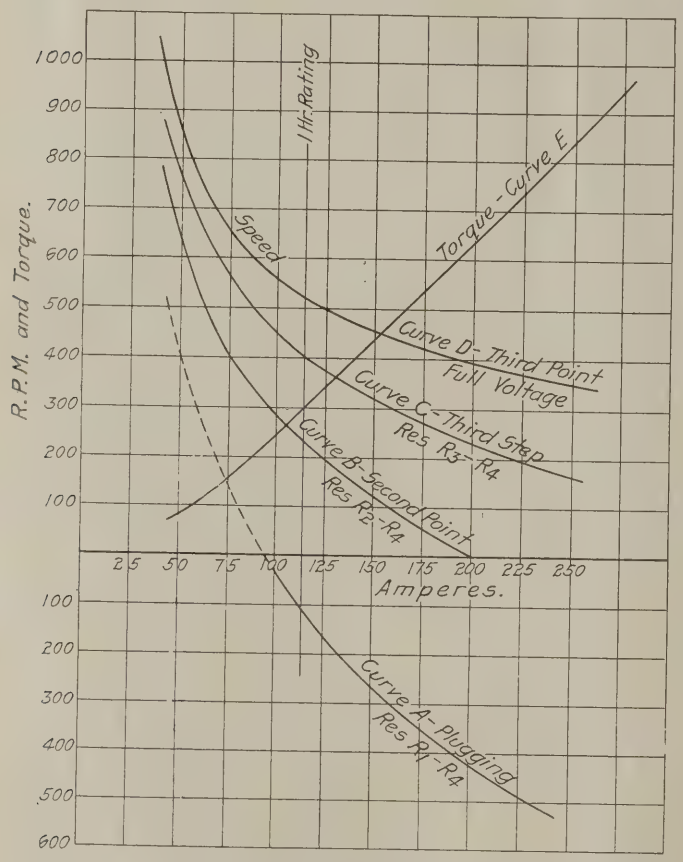


Fig. 11—Characteristic Curves of Series Motor With Accelerating Resistance

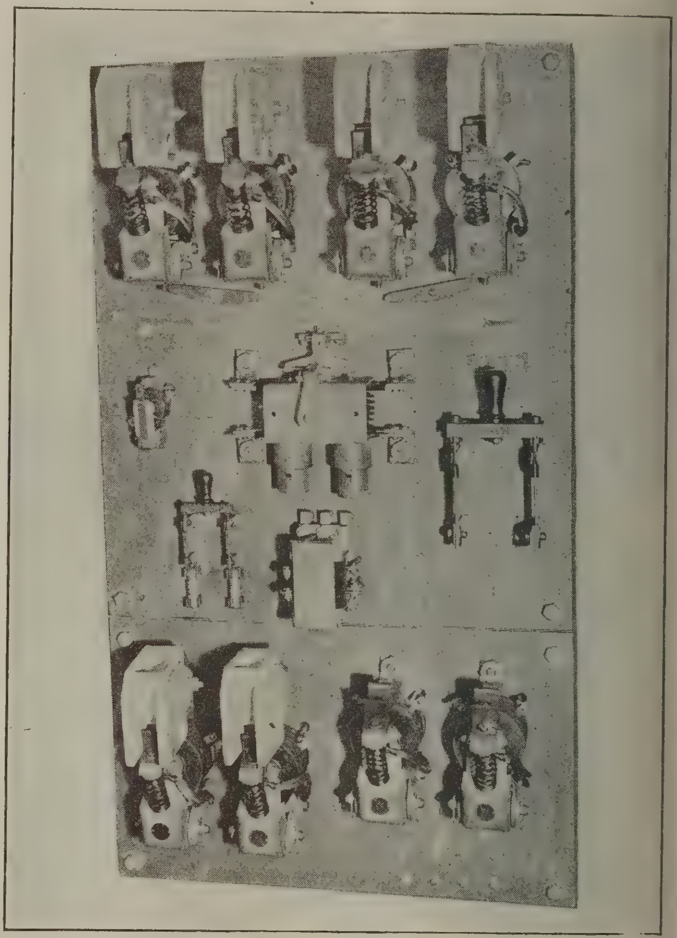


Fig. 12—Reversing Controller With Multipoint Current Limit Accelerating Relay

Reversing Controller with Multipoint Current Limit Accelerating Relay

A simple reversing controller with speed control and with plugging and accelerating currents limited by a single relay working on the current limit principle, is illustrated in Fig. 12. The connections are shown in Fig. 13. This equipment is similar to that using a plurality of series relays for current limit acceleration except that a single relay is here employed to perform the same functions as the several series relays.

The units comprising this controller are: a two pole knife switch to disconnect motor and control from the line; a control circuit switch, four directional contactors *1*, *2*, *3* and *4*, interlocked mechanically; a circuit breaker contactor *5*, three shunt wound accelerating contactors *11*, *12* and *13*; a multipoint accelerating relay; a voltage relay and a double coil overload relay. The action of the controller may be outlined as follows:

Off Position.—The voltage relay remains closed, independent of the master, giving no voltage release only. All other contactors are open.

First Point Forward.—The master completes a circuit through the closing coils of directional contactors *1* and *3* and circuit breaker contactor *5*. When these contactors close the motor is connected across the line with full accelerating resistance *R1-R4* in circuit.

Acceleration.—The accelerating resistance is cut out in steps by the accelerating contactors *11*, *12* and *13*. These contactors are governed by the accelerating relay the action of which will be briefly explained.

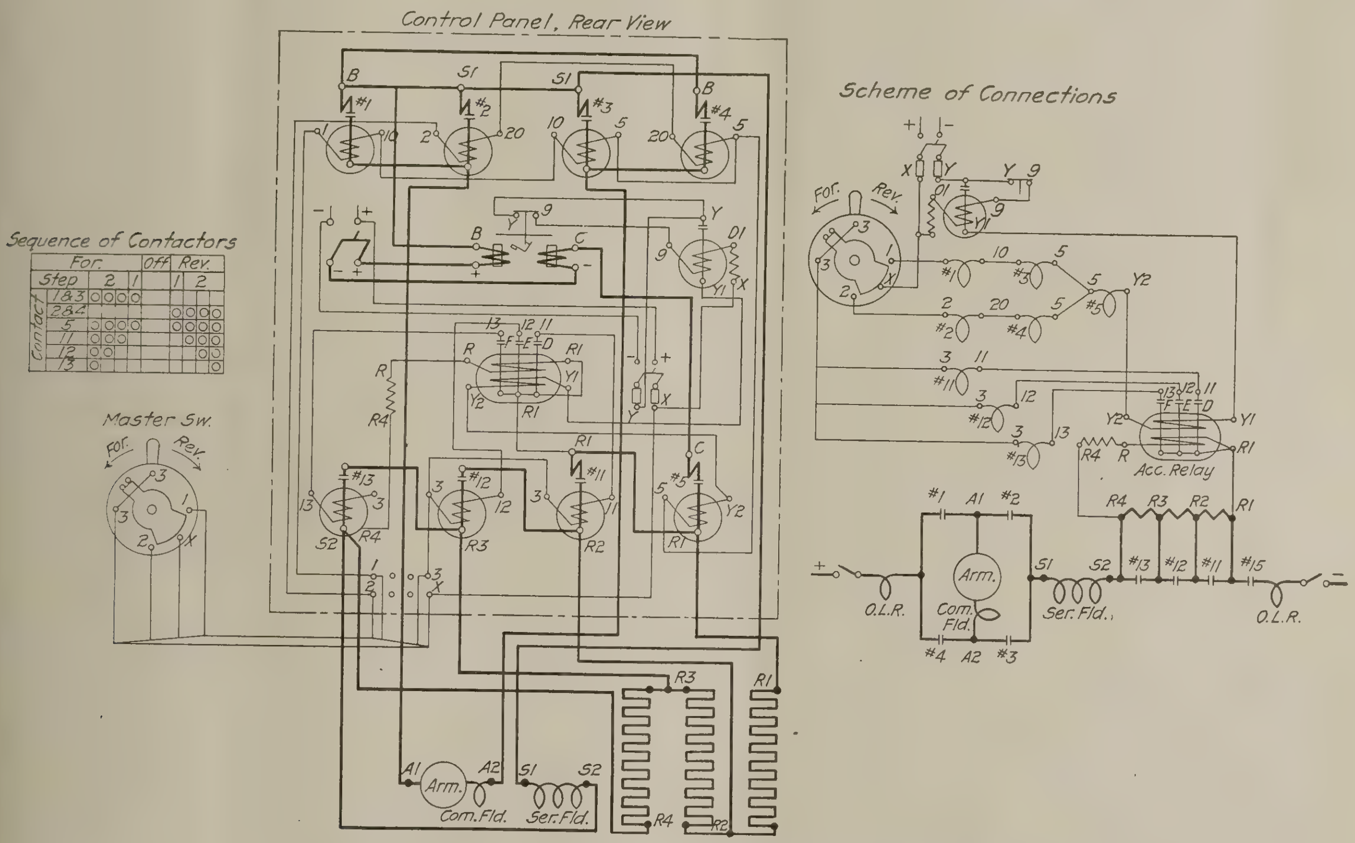


Fig. 13—Diagram of Connections—Reversing Controller With Multipoint Accelerating Relay

This relay is illustrated in Fig. 14. It comprises a magnet core having two coils. There are two sets of pivoted armatures. On one side are the accelerating armatures *D-E-F* provided with contacts. On the opposite side is the release armature *C*. The accelerating contacts are normally open, being held in this position by spring *H*. When the coil is magnetized the armature *C* closes releasing the accelerating armatures *D-E-F*. These armatures are retained by the magnet, however, against the pull of springs *K*. As the magnetism decreases the armatures *D-E-F* release and close their respective contacts. By properly adjusting the air gap, these armatures may be made to release at different values of magnetism, as desired. Each armature closes a contact which energizes the coil of an accelerating contactor.

It was remarked that this relay magnet is provided with two coils. Coil *A* is so connected as to have impressed across it the voltage drop of the accelerating resistance. Coil *B* is arranged to be energized to a constant value whenever the main contactors are closed to start the motor. When the motor is first started the full line voltage is taken up in the resistor. Relay coils *A* and *B* are both energized. Armature *C* is attracted and armatures *D-E-F* retained. As the motor accelerates, its counter-voltage increases so that the resistance drop decreases. The voltage across relay coil *A* decreases weakening the magnetism and allowing armature *F* to be released. This closes the control circuit for accelerating contactor *11*, short circuiting a section of accelerating resistance. The motor current now increases but, as the motor accelerates further its counter-voltage increases again reducing the voltage across the accelerating resistance and across relay coil *A*, which is connected across this resistance. The magnetism in the relay core now falls off permitting armature *E* to release. This closes contactor *12* which short circuits another step of accelerating resistance. Further acceleration of the motor permits armature *D* to release, causing accelerating contactor *13* to close, connecting the motor across the line. The voltage across coil *A* is now zero. Coil *B* remains energized, however, and furnishes sufficient magnetism to retain armatures *C* in the closed position.

Reverse Direction.—Operation in both directions is the same except that for the reverse direction, contactors *2* and *4* close instead of contactors *1* and *3*.

Plugging.—This control may be adapted for plugging service by insertion of sufficient plugging resistance *R1-R2* to act in conjunction with accelerating resistance *R2-R4* to limit the current peak. The drop across the resistance *R1-R4* will exceed line voltage when the motor is plugged. The relay must be adjusted accordingly.

Overload Protection.—Excess current through either or both overload relays will open circuit breaker contactor 5 and the directional contactors which happen to be closed at the time. The overload relay shown is of the hand reset type and remains open when tripped.

Remarks.—The controller here shown is merely one example of a wide variety of controllers which may be based on the principle and use of the multipoint current limit accelerating relay. The principal advantages offered by this arrangement over the plurality of individual current limit accelerating relays may be briefly enumerated.

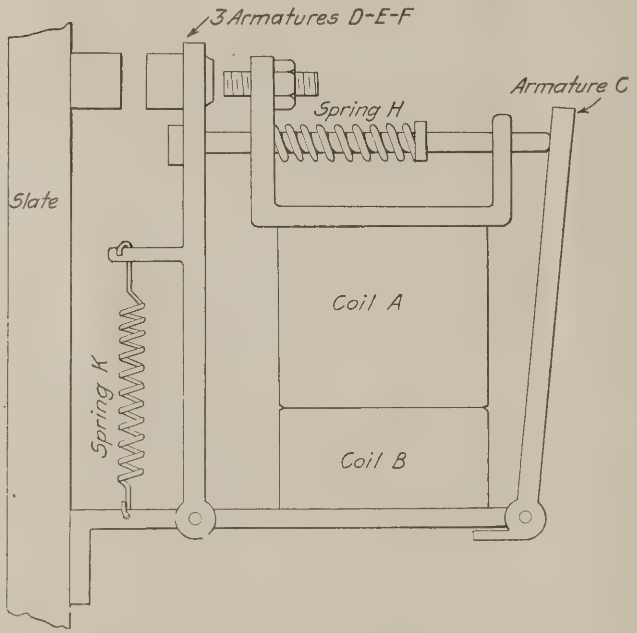


Fig. 14—Multipoint Accelerating Relay

A simpler and more compact controller results, having less parts, in less variety.

The amount of main circuit wiring and connections on the panel are reduced.

A multiplicity of different relay coils are required, according to motor rating, when series relays are employed. On the other hand one accelerating relay of the type described is applicable to an entire range of motors of a given voltage.

Series relays are subject to burnout from overloads. This danger does not occur in a relay of the above type.

The adjustment is simpler and a greater range of adjustment possible. It is sometimes necessary to change coils of series relays to secure the desired adjustment.

The Brotherhood of Locomotive Engineers has secured the approval of the Treasury Department to its application for a charter for the "Brotherhood of Locomotive Engineers Co-operative National Bank of Cleveland, O.," with a capital of $1,000,000. The application was filed by Warren S. Stone, grand chief of the Brotherhood.

Co-Operative Education a Success

For the past year an interesting experiment in co-operative engineering education has been conducted by the Massachusetts Institute of Technology and the General Electric Company. While the co-operative scheme in itself is not new, several departures from the usual plan were introduced, which have produced decided results.

The class was limited to thirty students, who were chosen entirely upon the records which they had made in the equivalent of the first two years' work of the electrical engineering course at the Institute. Included in this group were graduates from Yale, Harvard, Dartmouth, Princeton, the Naval Academy, besides men who had completed their first and second years solely at "Technology." The year (12 months) is divided into four three-month periods, the students spending alternately thirteen weeks at the Lynn works of the General Electric Company and eleven weeks at the Institute, followed by a two weeks' vacation. The group at Lynn is housed together in a fine old residence which has been converted into a modern club house. No break is made in the major studies when the students are at Lynn—classes being conducted at the works in principles of electrical engineering and in general studies. The progress of the students through the plant is regulated, not by the production needs of the various departments, but by the advantage which the experience in each department is to the students.

The result of this year's work has been gratifying to the originators of the plan. Because the students were a selected group, were all taking the same course, and were thrown together intimately at work and at the club house, an intense spirit of loyalty to one another, to the Institute and to the General Electric Company soon became manifest and every man strove to make a reputation for the course. With the students attacking the work in this frame of mind, it is not surprising that their enthusiasm was soon shared by the officials and superintendents of the co-operating company, who are unanimous in stating that the work done in the shops has been pre-eminently satisfactory. As evidence of its approval of the work, the company has increased the number of men who can be enrolled in this year's class to sixty and has already secured a new club house in order to furnish rooming accommodations for them. The new class entered upon the work July 6.

Powdered coal is to be used throughout for firing boilers and furnaces in the new sheet mill of the Falcon Steel Company now being erected at Niles, Ohio, The power plant boilers will be powdered-coal fired, using the Quigley compressed-air system for transporting and burning the coal. The pulverized coal will be transported from the milling plant through standard 4-in. diameter wrought pipes to furnaces and boilers for various distances aggregating approximately 800 ft. and will be switched from the main distribution line to a storage bin in the power house for use as required. —*Power.*

How the C. & E. I. Has Developed Car Lighting

Co-operation and the Employment of a Traveling Electrical Inspector Brought About Many Improvements

By Ernest Wilson

Traveling Electrician, Chicago & Eastern Illinois, Danville, Ill.

IT is important to know the conditions under which car lighting equipment must operate in order to obtain the best results. It is equally important to know how such equipment actually operates in service, in order to determine the causes of certain troubles that do happen, so that from the observations made methods can be developed for overcoming the difficulties. Most always the results have been an increase in efficiency and a large saving in material which otherwise would be required in order to give service at all.

The article published in the April issue of the *Railway Electrical Engineer* entitled "How Have the Railroads Developed Car Lighting?" recalls to mind a story that is told relative to a conversation between two Irishmen. Pat desired to learn from Mike, his confidential friend, how far a flea could jump. Mike after a brief pause replied, "Begorra, now, that is a quistion, but I belave if the flea uses his head he might find it unnicessary to jump at all, at all—he might dodge." The same thought might be applied to car lighting—that is, the secret of success in development work depends upon a combination of actions associated with the necessary knowledge of the subject to bring about the desired results.

What Development Work Depends Upon

All railroads in general have the same service to perform; they sell transportation to the public, freight and passenger. The management, of course, desires to render adequate service at minimum cost; and, insofar as the car-lighting department is concerned, it is up to the officers and employees of that department to assist in producing the results desired by the management. Service is the first requisite; it is supplemented by others of no less importance, but which qualify and determine what might be called, for simplicity's sake, the purity of the service. Among the supplementary requisites there are two which help to make service possible. These are adequate inspection and co-operation. Without the former the best equipment cannot serve its purpose continuously, and without the latter, inspection becomes a failure. It is through these channels that the development of car lighting by the railroads becomes a practical proposition, and it was largely through this means that the Chicago & Eastern Illinois was able to keep in service a substantial number of car-lighting equipments which otherwise might have been made obsolete and replaced by others considered more efficient.

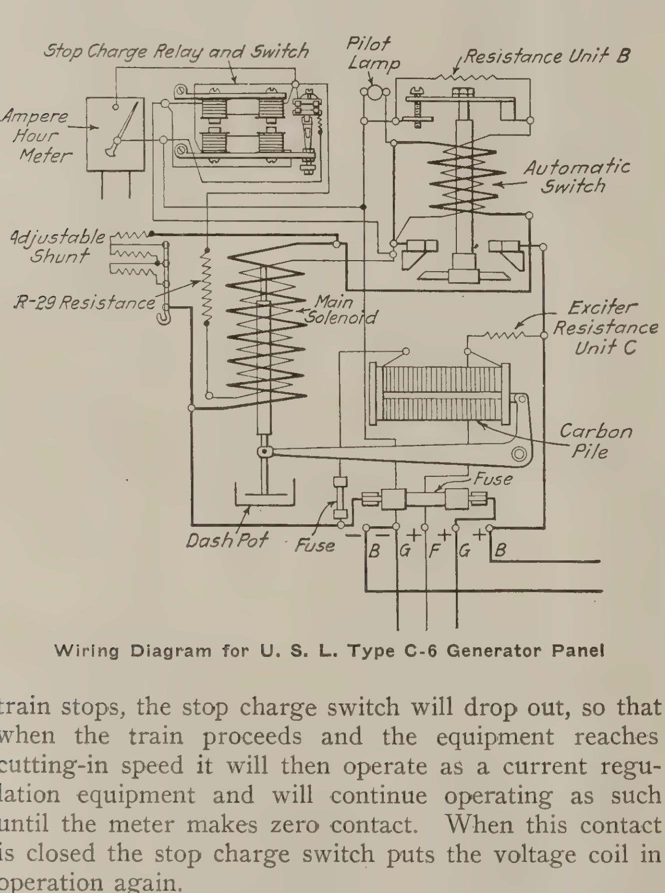
Several years ago the chief electrician of the C. & E. I. obtained authority for the services of a traveling electrical inspector whose duties are to travel practically continuously over the system and inspect, adjust and observe the operating characteristics of the car-lighting equipment in service on that road. By this means the chief electrician was able to get reliable information and operating data which brought about the development of certain apparatus described in another section of this article and establish co-operation not only between the chief electrician and the traveling inspector, but also with the various electrical foremen and employees of the different terminal yards where car-lighting equipments of the C. & E. I. cars are maintained. A knowledge of the conditions under which equipment operates and other information relative to the functions performed, not only in car lighting but in every line of endeavor, accounts for the efficient operation of different devices used for various industrial purposes. The traveling inspector has the opportunity of learning the exact conditions under which equipment operates and, through the system of co-operation, the maintenance forces get all of the facts which enable them to make repairs, etc., that bring about more efficient service.

Regulators Changed to Operate with Ampere Hour Meter

Further in regard to development work, the C. & E. I. is making use of the ampere-hour meter control in connection with some of its car-lighting equipment. In some cases it was necessary to make changes in the regulators in order to get the desired results. Those who are in a position to know the conditions under which car-lighting equipment is required to operate on that road are aware of the fact that in every case where an equipment has been changed to operate in accordance with the method as outlined in this article the service has been greatly improved.

The car-lighting equipment on the C. & E. I., with which the ampere-hour meter control is used, consists of several U. S. L. equipments with C-5, 6 and 7 regulators; one equipment with Safety D regulation, two equipments with Safety F regulation and a number of Safety F-1 equipments. Theoretically, the operation of the various classes of equipment is the same, but by using different resistance units on the different classes of equipment the results obtained are different. On the U. S. L. equipment, consisting of the C-5, 6 and 7 regulators with one exception, the C. & E. I. uses the following method of control: A resistance unit, U. S. L.-R29, is connected in series with the voltage coil, the latter being on open circuit until the ampere-hour meter has been made zero contact, otherwise depending entirely on current regulation. For instance, assume that a car has stood at a station, with all lights burning, a sufficient length of time to cause a discharge of 80 ampere-hours from the battery, it then resumes its trip. When the cutting-in speed of the car-lighting equipment is reached the main switch is closed and the equipment operates on current regulation only, which in the case of the C. & E. I. is 50 amperes during the summer months and 60 amperes during the winter months. When the equipment has put back in the battery what had previously been taken out while the car was standing at the station, plus the amount the ampere-hour meter is set to run slow for overcharge, the meter makes zero contact, thus closing a stop charge switch which consists of a type A Consolidated main switch rearranged by the C. & E. I., to accomplish the results desired. This re-designed stop charge switch is shown in the circuit diagram.

When this switch is closed the voltage coil is brought into operation, causing the battery to float at about 35 volts. The number of pins which are cut in to set the current regulation makes a difference of several amperes one way or the other. In most cases, however, the current output is about 15 to 20 amperes; this will take care of any small lamp load that might be used during the day time and yet is not enough to damage the battery by overcharging on any of the runs on the C. & E. I. If the lamp load is greater than the voltage regulation will permit the equipment to put up, and the ampere-hour meter hand moves from the zero contact the first time the train stops, the stop charge switch will drop out, so that when the train proceeds and the equipment reaches cutting-in speed it will then operate as a current regulation equipment and will continue operating as such until the meter makes zero contact. When this contact is closed the stop charge switch puts the voltage coil in operation again.



Wiring Diagram for U. S. L. Type C-6 Generator Panel

This method of control may be criticised because of the loss of the voltage coil protection in case of an open battery circuit. However, because of the excellent results obtained through rigid inspection of C. & E. I. equipment at the Chicago yards of the Chicago & Western Indiana, where a large part of the maintenance repairs and inspections are made, and because open battery circuits seldom occur, the C. & E. I. did not feel justified in sacrificing the advantage to be gained by the full load current output of the machine when needed for the voltage coil protection of an open battery circuit; and as C. & E. I. equipments float with the voltage coil in operation about 75 per cent of the time, there is very little danger from an open battery circuit.

In regard to battery inspection, it might be of interest to know that upon the arrival of a car at the yards a gravity reading is taken of the pilot cell and an inspection is made to discover any leakers or loose connectors. Every three months the batteries are flushed a little. They could run five or six months without flushing on some of these equipments, but the C. & E. I. believes that better results are obtained by flushing more often. At such times a general inspection of the battery is made; and by flushing every three months the batteries do not require water to the extent that it is necessary to charge them to death in order to get the gravity up to where it should be.

On Safety F-1 equipment the C. & E. I. uses the ampere-hour meter control as a current saving device; these are combination equipments consisting of a Consolidated type A dynamo and a Safety F-1 regulator. Since the dynamo is only a 900-watt machine and the load is about 14 amperes, and since the equipment is used mostly on local and night runs, the longest of which is 300 miles, the C. & E. I. had to figure very closely to keep from buying new dynamos. However, by using the above described method of ampere-hour meter control on this equipment the two amperes of current required by the Safety F-1 voltage coil could be saved and a current output of 30 amperes could be had as long as required. In this case, when the meter has put back what has been taken out of the battery, plus the overcharge setting of the meter, and the meter makes zero contact, it closes the stop charge switch, which is the same class of switch as described for use on the U. S. L. equipment shown in the illustration. The closing of this stop charge switch puts the voltage coil in operation and floats the battery at 38 volts for this equipment while taking care of the lamp load also, and if there is such a thing as the battery and meter getting out of step under ordinary operating conditions the voltage operation should put them in step again, although the C. & E. I. has never had any trouble of this kind. When the C. & E. I. applies a meter it is always sealed, and the only persons having authority to break the seal, or have it done, are the chief electrician or the traveling electrical inspector; therefore when there is any trouble with the equipment and the battery requires charging from an external circuit it gets an overcharge equivalent to whatever the ampere-hour meter indicates has been taken out of the battery, as the car equipment has to work the meter hand back to zero before the equipment will be a voltage regulation equipment again; this is the only reason, if there is any, that the C. & E. I. battery and meters do not get out of step, and since each equipment does not fail even once a year, it is easy to see why C. & E. I. batteries do not have much help to keep them in step. Once in a while a meter is set back to 490, but that is an exception rather than a rule. In most of the cases it is an equipment that floats a greater part of the time and does not offer an opportunity to stir the battery up as it should be, so that the trouble falls as much to the voltage control as to the meter control.

Relative to voltage control equipments, the C. & E. I. have a number of Safety F-1 regulators and Consolidated type A dynamos. The adjustments that are made on these are as follows: The voltage coil, with insulated main switch, is adjusted to 38 volts, then with open voltage coil the current coil is set at 40 amperes; this will give a voltage regulation of approximately 32 amperes;

at 35 volts. The C. & E. I. has not had any trouble with these equipments. If any trouble developed it would not be charged to the voltage regulation but to the small dynamo. No complaints have been made in regard to the general condition of the battery or the flushing on these equipments. In conclusion, it might be well to state in regard to the ampere-hour meter that so far the C. & E. I. have not found it necessary to employ an expert artisan to clean and adjust ampere-hour meters, as the writer does this himself; that is, he cleans both mercury chambers and recharges the magnets and adjusts them to C. & E. I. requirements.

Principles of Car Lighting By Electricity

A Course of Practical Lessons Explaining the Main Details of this Important Application

By Chas. W. T. Stuart

I. The Straight Storage System

Car lighting by electricity had its beginning in 1885, receiving wide attention by American railroads about 1900. In this country today approximately 42 per cent of the total railway passenger cars are illuminated by electricity, and this system is preferred for new equipment. One reason for this preference is the marked improvements that have been made in the manufacture of incandescent lamps which will be described in full detail later.

During the experimental stage of car lighting by electricity, that is, from 1885 to 1900, three general methods were developed, all of which are in use today. These three methods are—the straight storage system—the head end system—the axle generator system.

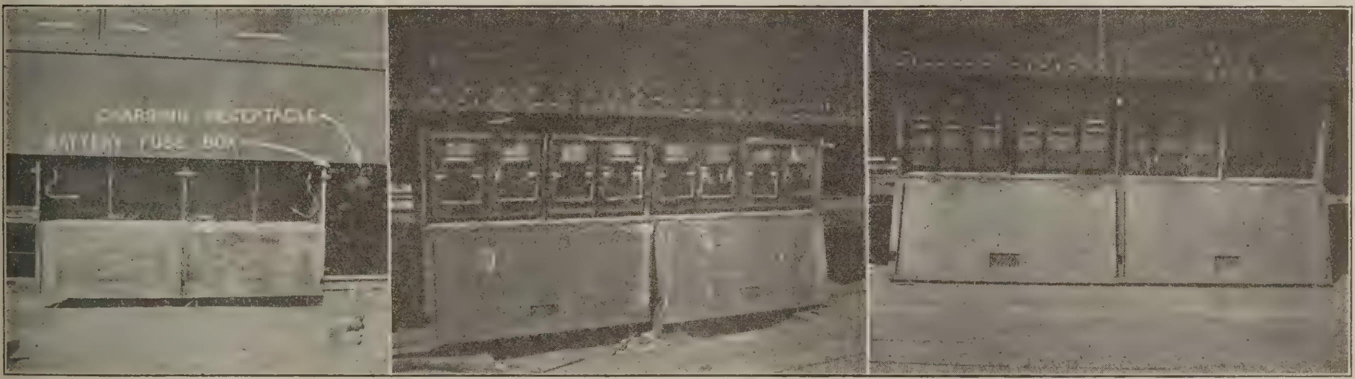


Fig. 1—Three Views of Battery Boxes, Showing Location of Charging Receptacle and Battery Fuse Box

Straight Storage System

The straight storage system is a system in which the current for lighting the car is supplied exclusively by storage batteries, either as individual units on each car or one battery for lighting several cars. The battery for a 30-volt system contains 25 Edison cells or 16 lead cells, while the battery for a 60-volt system contains 50 Edison cells or 32 lead cells. The battery is carried in specially designed boxes which are suspended from the car body, as shown in Fig. 1.

Battery fuses are mounted on each side of the car in iron boxes which are constructed for the purpose. Two wires carry the current from the battery and battery fuses to a switchboard or distribution panel which is located inside the car. Upon reaching this switchboard the current is distributed through protecting fuses and control switches to the various lamp circuits. Anderson type-C, 125-volt, 100-ampere charging receptacles are mounted on each side of the car to provide connections for charging the battery at the railroad terminals. These receptacles are shown in Figs. 1 and 2.

To study this system more fully suppose we construct a simple straight storage system, by taking the various parts as shown in Fig. 3, and connecting them step by step.

First step.—Run two service wires or battery wires from battery to the battery fuses, then to the switchboard, as shown in Fig. 4.

Second step.—Connect the two wires from each lamp circuit to the switchboard, as shown in Fig. 5.

Third step.—Connect the two charging receptacles to the main battery wires, as shown in Fig. 6, which is a complete wiring diagram of a simple straight storage system. Two charging-receptacles are connected so that the battery may be charged from either side of the car.

Now that we have constructed a complete straight storage system, it might be interesting to study the path of the charging and discharging currents.

Fig. 7 shows a straight storage system with the lights burning, that is, with the lighting switches all closed. The arrows point in the direction of the flow of current. Starting at the + battery terminal the current flows through the + battery fuse to the + terminal of the switchboard when it branches off in four directions, sending one wire to each lamp circuit. Passing through the lamps the current returns through four wires, one from each lamp circuit to the — terminal of the switchboard when it returns through the — battery fuse to the — battery terminal.

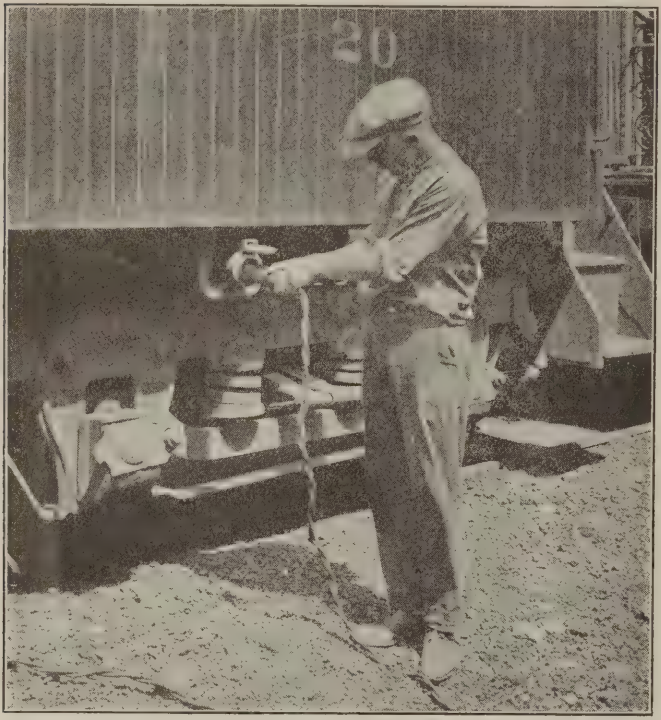


Fig. 2—Placing Plug From Yard Charging Plant Into Anderson Type "C" Charging Receptacle

Trace the charging current by following the arrows in Fig. 8. The charging current from the yard charging plant enters through the + side of charging receptacle, flows through the + battery fuse to + battery terminal, through the battery to the — battery terminal, returning to the charging plant through the — battery fuse and the — side of the charging receptacle. You will note by comparing Figs. 7 and 8 that the charging current flows through the battery in the opposite direction to the flow of the discharging current. The lights should *not* be on while the battery is charging as the voltage on the lighting circuits is increased while the battery is on charge.

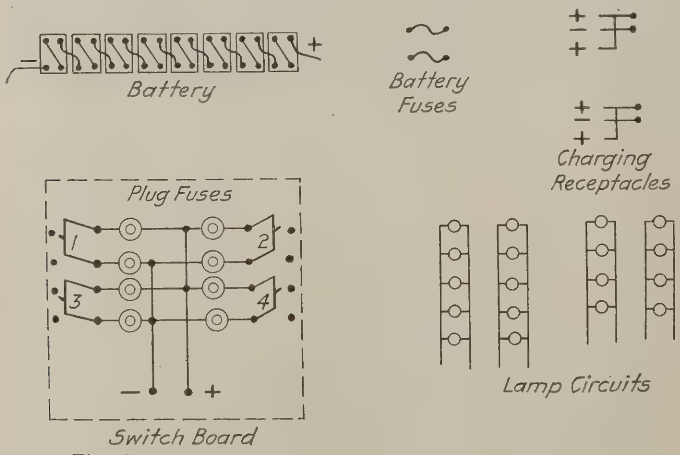


Fig. 3—Parts of a Simple Straight Storage System

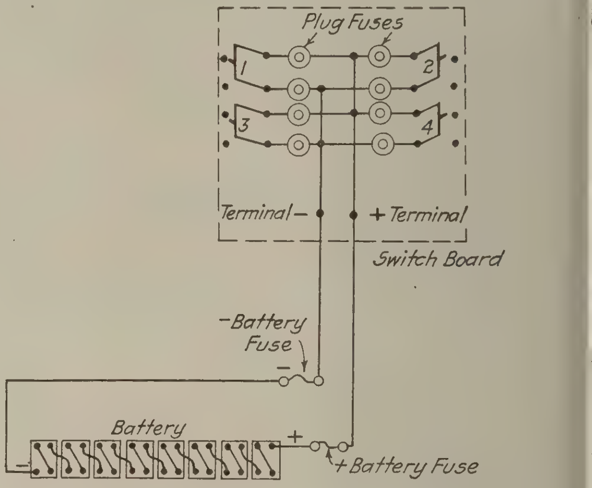


Fig. 4—Battery and Panel Board Connected

Some straight storage systems are equipped with Sangamo ampere hour meters and stop-charge, shunt-trip circuit breakers. The meter and circuit breaker are both mounted on a slate panel which is known

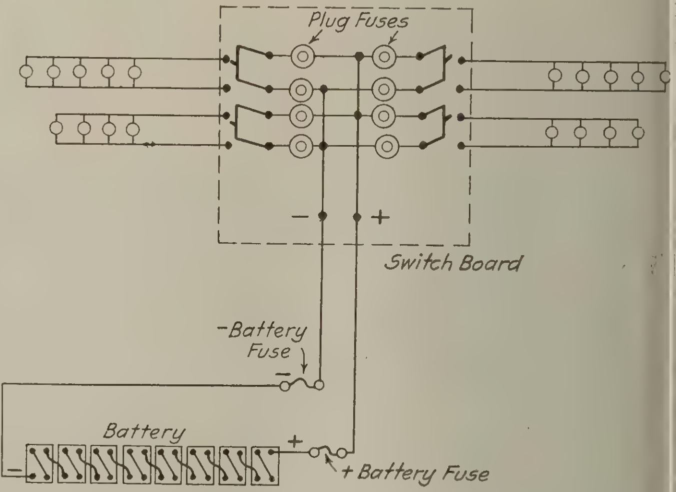


Fig. 5—Battery, Panel Board and Lamp Circuits Connected

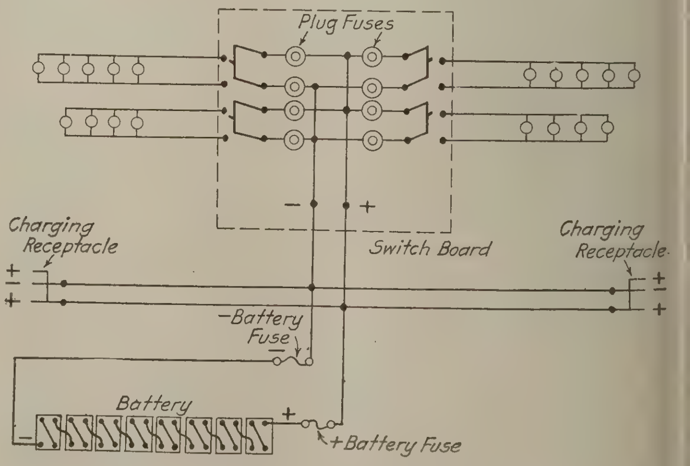


Fig. 6—Parts of a Simple Straight Storage System Connected

as the Sangamo control panel illustrated in Fig. 9.

The function of the control panel is to give an indication of the battery charge and discharge and to limit the charge by automatically opening the stop-charge circuit breaker.

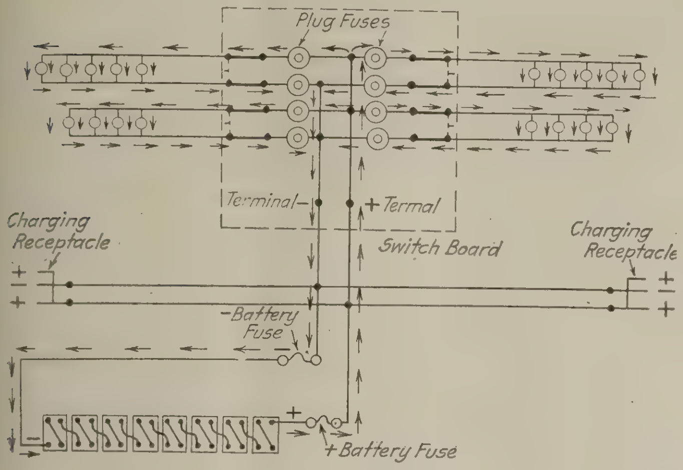


Fig. 7—Straight Storage System With Lighting Switches Closed and Arrows Indicating Direction of Current Flow

Fig. 10 is a wiring diagram of a straight storage system equipped with a Sangamo control panel. If you will trace the flow of current in Fig. 10 as we did above in Figs. 7 and 8 you will find that the charging current passes through the Sangamo meter in one direction and the discharging current the other. This change of direction of current moves the hand on the meter dial accordingly and when the battery is fully charged the hand on the meter dial will close switch *A*, Fig. 10, which in turn opens circuit breaker *Y* and stops the charge. A full description of the Sangamo meters used in car lighting will be given in detail in a following lesson.

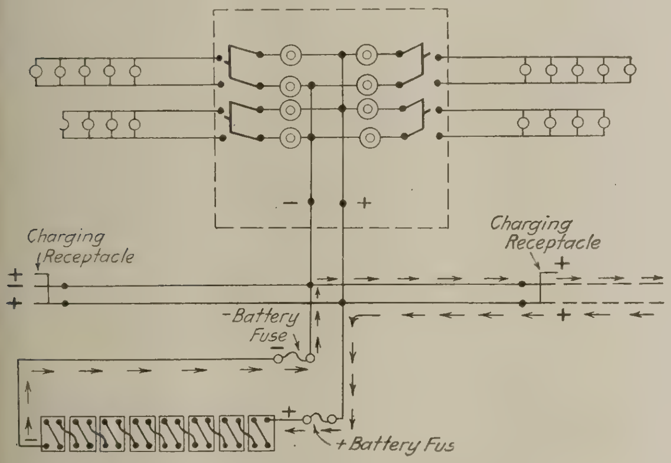


Fig. 8—Battery on Charge, Showing Lighting Switches Open

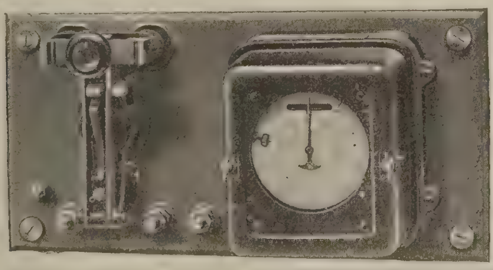


Fig. 9—Special Train Lighting Panel for Pennsylvania Railroad With Sangamo Ampere Hour Meter and Circuit Breaker

Increasing the Storage Capacity for Special Cars

In some special cases it is desired to increase the storage capacity of the battery by using more than one set of batteries and connecting them in different ways for charging and discharging by using standard voltage lamps and the standard charging equipment.

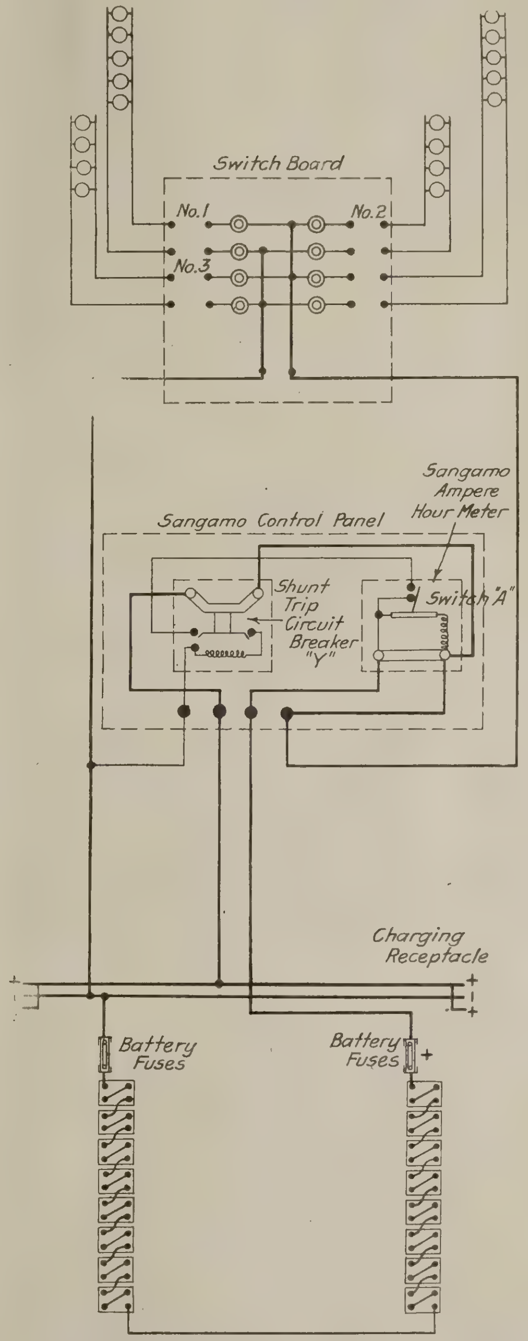


Fig. 10—Straight Storage System Equipped With Sangamo Control Panel

For example, Fig. 6 is a diagram of a 30-volt straight storage system with one 30-volt set of batteries. If each cell had a capacity of 300 ampere hours, the total capacity of the battery at 30 volts would be 300 ampere hours. If the lamp consumption was 600 watts, the lamp current will be 600 ÷ 30, or 20 amperes, and with a lamp current of 20 amperes the battery will light the car for 300 ÷ 20, or 15 hours.

Now to increase the storage capacity of this car we have a choice of two schemes. We can use two sets of batteries in series and change the lamps in the car to the standard 60-volt lamps or we may connect two 30-volt sets of batteries in multiple using the standard 30-volt lamps.

Fig. 11 shows two 30-volt sets of batteries in series. The ampere hour capacity of the battery using 300-ampere hour cells will be same as above, 300 ampere hours, but the voltage on the lamps is increased to 60 volts. With a lamp consumption of 600 watts the lamp current will be 600 ÷ 60, or 10 amperes. And with a lamp current of 10 amperes the battery will light the car for 300 ÷ 10, or 30 hours. You will note that this is just double the time that one set of batteries will light the car.

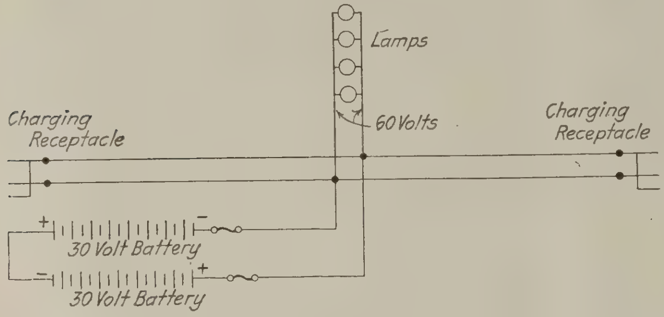


Fig. 11—A 60-Volt Straight Storage System—Two 30-Volt Sets in Series

Fig. 12 shows two 30-volt sets of batteries connected in multiple on discharge and in series on charge. The charging in series is preferred because the two sets will charge more evenly in series than in multiple.

The ampere hour capacity of the battery in this case using the 300 ampere hour cells will be 300 times 2, or 600 ampere hours. With a lamp consumption of 600 watts at 30 volts the lamp current will be the same as in Fig. 6, which is 600 ÷ 30, or 20 amperes, and the battery will light the car for 600 ÷ 20, or 30 hours, the same length of time as in Fig. 11, where we had two 30-volt sets of batteries in series.

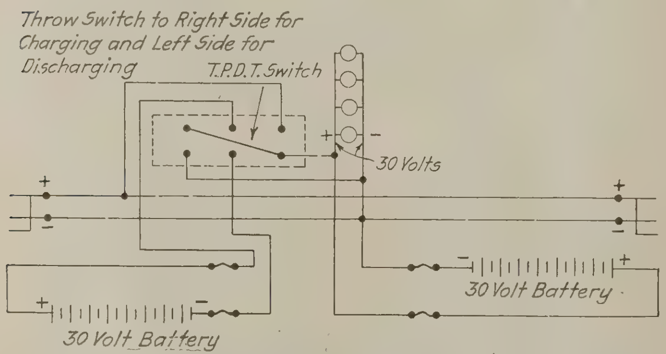
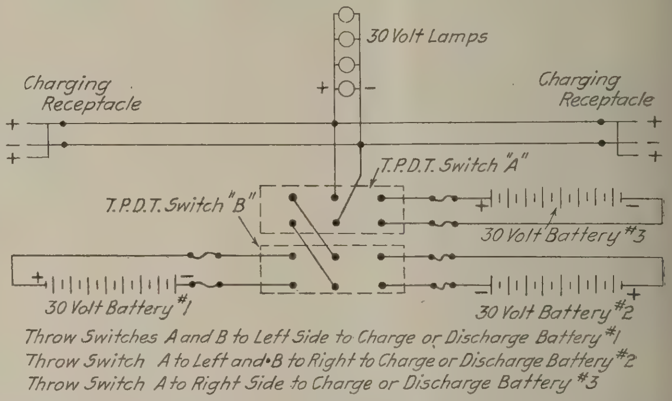

Throw Switch to Right Side for Charging and Left Side for Discharging

Fig. 12—A 30-Volt Straight Storage System Having Two Sets of Batteries Connected in Multiple on Discharge and in Series on Charge

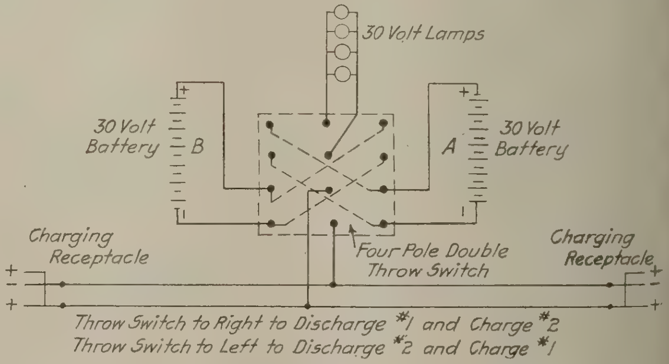
To make the storage capacity still greater three 30-volt sets of batteries may be used as follows:

Fig. 13 shows three 30-volt sets of batteries connected to two 2-pole double throw switches. By throwing switches *A* and *B*, Fig. 13, to the left side you charge or discharge battery No. 1 and batteries No. 2 and No. 3 are held in reserve. By throwing switch *A* to the left and switch *B* to the right side, Fig. 13, you charge or discharge battery No. 2 and have batteries No. 1 and No. 3 in reserve. Throw switch *A*, Fig. 13, to the right side and you can charge or discharge battery No. 3 and hold batteries No. 1 and No. 2 in reserve. The ampere hour capacity of the battery in this case using 300 ampere hour cells will be 300 times 3, or 900 ampere hours. With a lamp consumption of 600 watts at 30 volts the lamp current will be 600 ÷ 30, or 20 amperes; and the three sets will light the car for 900 ÷ 20, or 45 hours, just three times as long as in Fig. 6, where we use only one set of batteries.



Throw Switches A and B to Left Side to Charge or Discharge Battery #1
Throw Switch A to Left and B to Right to Charge or Discharge Battery #2
Throw Switch A to Right Side to Charge or Discharge Battery #3

Fig. 13—A 30-Volt Straight Storage System Having Three Sets of Batteries—One Set in Service and Two Sets in Reserve



Throw Switch to Right to Discharge #1 and Charge #2
Throw Switch to Left to Discharge #2 and Charge #1

Fig. 14—A 30-Volt Straight Storage System With Two Sets of Batteries

Lighting from One Set While the Other Set Charges

We stated above the lights should be off while the battery on a straight storage system is charging, due to increased lamp voltage, and you will note that in Figs. 6, 11, 12 and 13, there is no way to get light on the car while the battery is charging without placing the increased voltage on the lamps. A scheme for overcoming this by using two sets of batteries is shown in Fig. 14. Either set of batteries may be charged while the other is furnishing current to light the car. Throw the 4-pole double throw switch, Fig. 14, to the right side and you may charge battery *A* and discharge battery *B*. Throw the 4-pole switch to the opposite or left side and you may charge battery *B* and discharge battery *A*.

All the above schemes are in use in special cases today on the various railroads.

Advantages and Disadvantages of the Straight Storage System

The straight storage system has the advantage over the other methods of car lighting by electricity as it is very simple, not having any complicated mechanism. It is also reliable, having a positive source of current as long as the battery charge lasts.

It has one big disadvantage, however, in that it requires that the cars be taken out of service and placed in the terminal yards from six to eight hours for recharging batteries. This system also requires an expensive charging plant at each terminal, the wiring of which must be designed so that cars can be charged while on any track in the car yard and the generator must be large enough to charge the maximum number of cars at one time.

Alternating Current Theory and Practice

A Brief Practical Review of Basic Principles Prepared for Railroad Electrical Workers

By O. C. Callow

VII. Power Factor

It was shown in the preceding article that if an alternating current circuit contained resistance only and no reactance the current and voltage would be in phase with one another; also that if inductance were contained in the circuit, the current would lag behind the voltage, while in the case of capacity in the circuit the current would lead the voltage.

Let us now consider what effect this lag and lead has upon the circuit. Referring to Fig. 1, which represents the current lagging in an inductive circuit, it will be noticed that there are times when the voltage is in one direction and the current in the opposite direction such as at *X*. Since the current and voltage will tend to buck one another at certain points in the cycle, there must be a loss of power. The product of the instantaneous values during the time which the above conditions exist is known as negative power. Negative power can then be considered as power that has been transmitted to the load, but has been returned back to the generators unused, resulting in a loading of the circuit for which no useful work is performed.

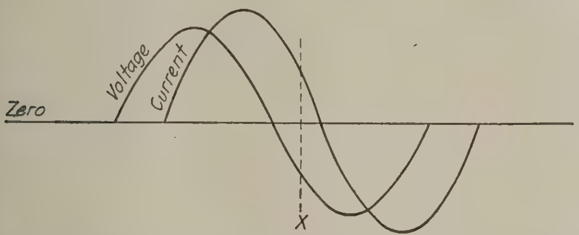


Fig. 1. Showing Current and Voltage in Different Directions in Circuit With Inductance.

Fig. 2 shows a curve which has been plotted from the instantaneous values of the current and voltage curves similar to those in Fig. 1. This is done by measuring vertical lengths at different points on the curve, such as at *AB* and *AC*. Since the power or watts in the circuit equal the current multiplied by the voltage, the length *AB* must be multiplied by the length *AC;* this will give a point *D* on the power curve. This is continued for the complete curve for as many different points as may be required. The resultant curve will be found to project below the zero line in two places. It is this portion of the curve which represents negative power in the circuit and which, in this instance, is produced by the current lagging 40 degrees behind the voltage. It will be noted that the second portion of the power curve is positive or above the zero line, although the voltage and current curves were shown negative at this time. The reason for this is explained by the fact that the product of two negative quantities is positive. It should be noted that a similar effect is obtained in a circuit containing capacity instead of inductance. Fig. 3 shows a power curve representing such a circuit showing the negative power again below the zero line.

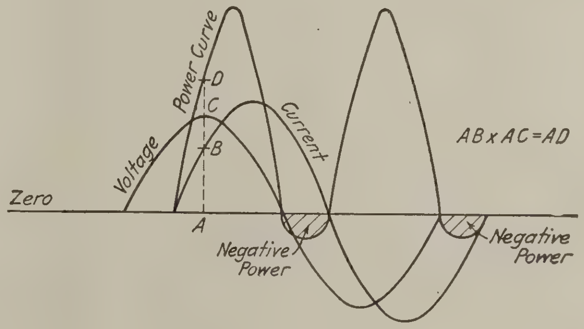


Fig. 2. Showing Power Curve Plotted from Current and Voltage Curve of Inductive Circuit—Current Lagging. Negative Power is Shown Shaded. Power Curve is Drawn on Smaller Scale Than Current or Voltage Curves, for Convenience

Since this loss due to negative power must be present in almost every alternating current, since practically all circuits contain inductance, there must be a method of measuring same. If we have a circuit feeding a single-phase motor and connect an ammeter, voltmeter and wattmeter in the circuit as shown in Fig. 4 we shall find that the product of the instantaneous readings of the ammeter and voltmeter are higher than the wattmeter reading. Assuming that the ammeter reads 10, the voltmeter 100 and the wattmeter 800, the product of the ammeter and voltmeter reading will equal 1000, but this is not true watts. It is known as apparent watts or "volt amperes" and is a measurement of total power plus the negative power. The wattmeter reading of 800 watt represents the true watts or actual power available in the circuit. The coefficient by which the apparent watts must be multiplied to equal the true watts is known as the "power factor." Power factor can then be expressed in the equation

$$\text{Power factor} = \frac{\text{true watts}}{\text{apparent watts}} = \frac{\text{wattmeter reading}}{\text{volts times amperes}}$$

$$\text{Thus in the above circuit P. F.} = \frac{800}{1000} = .8 \text{ or } 80\%.$$

The negative power in this circuit is therefore 20% of the useful power and for every 1000 watts used there is 200 watts returned unused. It is therefore obvious that a low power factor must be guarded against in every possible manner, since induction motors, arc lamps, welding furnaces, etc., are all inductive loads which cause lagging power factors. Capacity will cause low power factor, since there is negative power when the current leads the voltage. In capacity circuits the power factor will be leading. Overexcited synchronous motors and unloaded transmission lines are the more common conditions that will cause this effect.

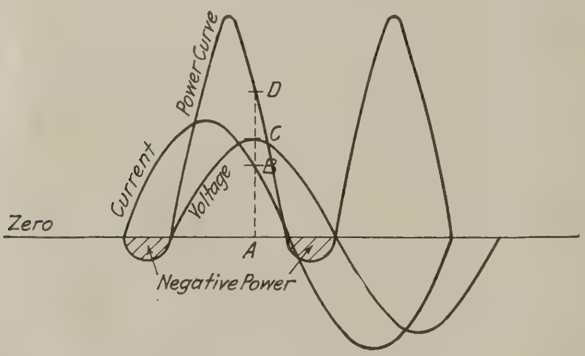


Fig. 3. Showing Power Curve Plotted from Current and Voltage Curves of Circuit Contracting Capacity—Current Leading. Negative Power Is Shown Shaded

The power factor can vary between 0 and 100. At zero power factor the current and pressure will be 90° out of phase, Fig. 5, and the useful power will be equal to the negative power, hence there would be no power available. This condition is hardly ever encountered in practice. About the lowest factor which would be encountered would be 20%, in the case of an unloaded induction motor, in which case the useful work done is simply overcoming friction and supplying the losses of the machine. For this reason induction motors should be loaded to capacity, since their power factor is generally highest at full load.

The following example is interesting to show the saving which can be made in copper in a transmission line, if a high power factor can be maintained. A 3-phase line is required to transmit 1000 kw. at 6000 volts over a distance of 5 miles with a drop not over 10 per cent. If a power factor of 90 per cent can be maintained, each conductor would have an area of about 97,500 circular mils. If, however, the power factor were only 60%, each conductor would have to be about 218,000 circular mils, or 2.2 times as heavy. Again, if a certain load draws a current of 1000 amperes from the power house at 100% power factor, then, if the voltage is constant, it will draw 2000 amperes at 50% power factor. Since the heating losses in the generators, transformers and lines are proportional to the square of the current, these losses will increase greatly with low power factor.

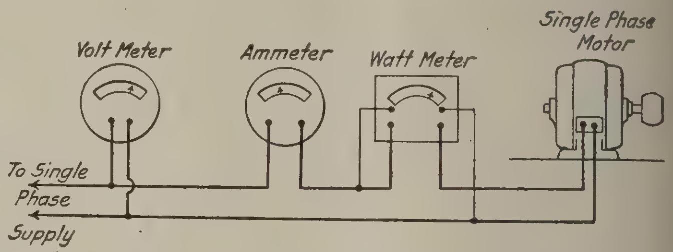


Fig. 4. Connections for Measuring Power Factor on Single Phase Circuit Using Voltmeter, Ammeter and Wattmeter

In measuring power supplied to a consumer, a watt-hour meter is used; this meter will read the true watts of the circuit only, hence if the power factor of the consumer's load be low, the power house must supply a large amount of power for which it will receive no payment. For this reason many companies give a bonus if the power factor is kept above a certain value. Others will charge a higher rate per kw. hour if the power factor be found to drop below a certain value.

In rating alternating current generators and transformers, it will be found that their output is seldom expressed in kilowatts, a machine is said to have an output of, say, 100 kva. (kilovolt amperes), meaning its apparent output in kilovolt-amperes. When the power factor is 100 per cent the kva. will equal the kilowatts, but at any other power factor it will be higher, being the apparent value. Therefore, a generator rated at 100 kva. as its full load output would be good for 80 kw. at 80 per cent power factor. This method has been

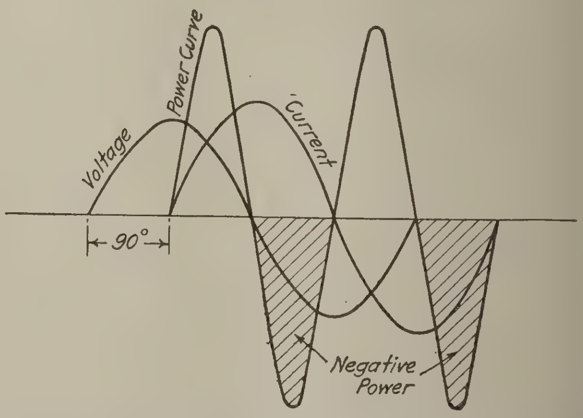


Fig. 5. Showing Current Lagging 90 Degrees Behind Voltage. In This Instance the Negative Power Will Equal the Useful Power, Hence no Power Will Be Available for Useful Work. The Power Factor Would Equal Zero in This Circuit.

adopted to avoid confusion which might arise in purchasing a machine at its kw. rating and then trying to obtain this output at a low power factor.

It is apparent, therefore, that every effort should be made to keep the power factor of all equipment as high as possible. As stated above, lightly loaded induction motors and transformers cause low power factor; care should therefore be exercised in selecting motors which are the correct size for each drive, and when no work is being done they should be shut down. These remarks also apply to transformers. If it is found impossible to bring the power factor of a plant or system up by correct loading of the equipment, some form of condensor may be placed in the circuit. As explained before, a condensor contains capacity, and capacity will cause the current in a circuit to lead the voltage. Thus, if capacity be connected in a circuit which has a low power factor caused by the current lagging, due to induction, the resultant power factor will be improved, since the capacity will tend to make the current lead.

In practice, this effect can be produced by means of a synchronous motor or rotary convertor with over-excited field or by a long unloaded high tension transmission line, both of which contain considerable capacity. In many systems it has been found that the installation of a synchronous convertor, as these synchronous motors are termed, when used for power factor correction, has resulted in a great saving and has enabled much more load to be carried by the power house generators than formerly.

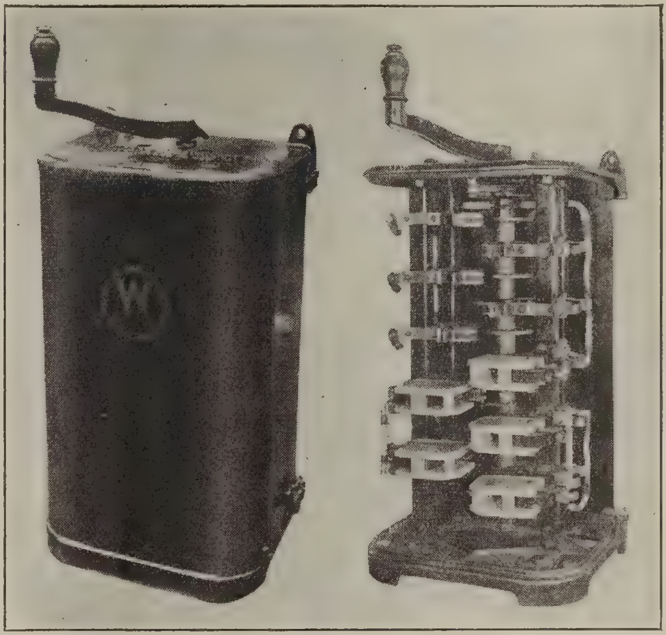
Drum-Contactor Controllers for D. C. Motors

A new type of manually operated, drum controller, known as the Type S drum contactor, has been developed by the Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa. It embodies practically the same principles of operation as the magnetic contactor controllers, and the originators believe it will cause great changes in present controller construction. During the past year, exhaustive tests made on these controllers have indicated that in construction they are superior to the drum and face plate controllers formerly used. They are adapted for starting and adjusting the speed of shunt, series and compound-wound, direct-current motors by adjusting the resistance in series and parallel with the motor armature. They are applicable also to cranes, hoists, roll and transfer tables, and practically all applications employing this system of control.

In operation, the Type S controllers employ the same principles as magnetic-contactor controllers, except that he contactors are operated by cams mounted on the controller shaft. Normal movement of the controller handle causes the contactors to open or close with a quick, positive action which reduces arcing. The arcing is further controlled by the rolling motion of the contacts, which limits all arcing and burning to the contact tips. Final contact is made with a slight wiping motion, which insures clean contact surfaces and maximum current-carrying capacity. The line contactors, which open and close the main line circuit, are protected by magnetic blow-outs, which aid in extinguishing any arcing that may occur.

Each contactor is closed by a hard fibre cam, operating on a practically frictionless roller on the moving contact element, and opened by a strong compression spring when the cam is moved away from the roller. This prevents the shaft from becoming locked by an accident to a single contactor, which would otherwise prevent opening of the circuit. Each contact element is complete in itself, and can be removed as a unit.

All controllers are drilled and tapped for both a horizontal and vertical handle and can be supplied with either. The horizontal handles of controllers in service can be readily replaced with vertical handles or vice versa. The vertical type is fastened to the top of the controller by four bolts spaced equally distant from the controller shaft and from each other. This permits it to be mounted in any one of four positions, 90 degrees apart, to facilitate placing the controller in the most convenient position, and still provide easy operation from front, back or either side. In addition, this feature enables the movement of the handle in many installations to be in the same direction as, and to be used to indicate the movement of the hoist, crane or other device. Each controller embodies all such desirable features as conduit wiring, enclosed current-carrying parts, protection against the controller being locked in running position, as well as positive prevention of accidental starting or reversing.


Westinghouse Type S Drum Contactor Controller

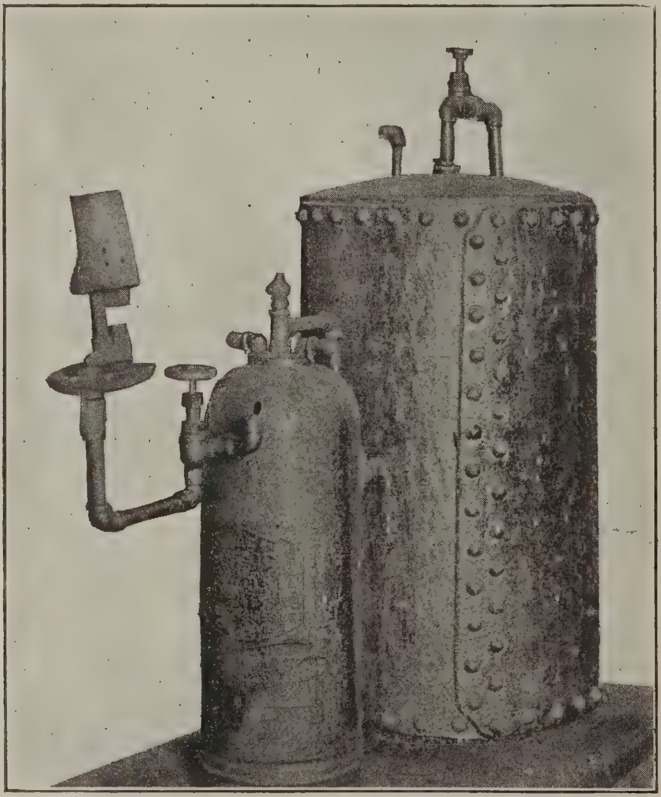
The new Westinghouse controller is supplied both with and without dynamic braking. Controllers for use with crane hoists regulate the speed of the motor while lowering by dynamic or regenerative braking. They are so designed that if there is not sufficient weight on the hook or cage to revolve the motor and drums, the motor will assist in the lowering. The speed of the motor is always under the accurate control of the operator, both when hoisting and lowering, regardless of the load. Cranes equipped with these controllers can have high, safe lowering speeds, if the particular motor used is capable of standing such operation.

PRACTICAL STUNTS

A Kerosene Burner for Heating Battery Compound

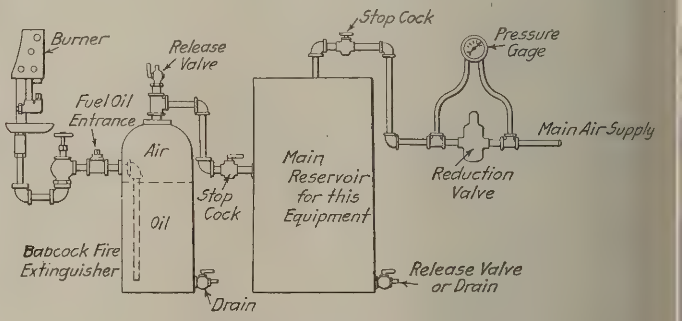
By A. R. Wicklander, Electrical Foreman
Chicago & Western Indiana

The apparatus shown in the photograph and sketch illustrates the method of heating battery compound used on the Chicago & Western Indiana, in its battery charging plant at Chicago. This scheme is considered much better than the old method used at this plant. Formerly all battery compound was heated by an ordinary gasoline torch, which was slow work and at the same time more or less hazardous. The new arrangement employs an old Babcock fire extinguisher to hold kerosene. This container when partly filled with the fuel oil is subjected to air pressure of from 10 to 15 lb. The latter figure is about as much as the fire extinguisher will stand. Compressed air is obtained from a main supply through a reduction valve and stored in what might be considered for this equipment, a main air reservoir. This reservoir consists of a cylindrical tank similar to those ordinarily used on coaches. It serves as a moisture gathering vessel and also aids in balancing the air pressure on the reduced side.



An Old Babcock Fire Extinguisher Used As a Fuel Oil Container for Furnishing Oil to Burner; Pressure Tank in the Rear

The burner consists of a second-hand affair and is similar to those used on water sterilizers. The sketch shows the details of the apparatus, the pipe line connections and the various valves and drains. It will be noted that a pressure gage is included with this equipment. Its purpose, of course, is to register the air pressure both in the main supply line and the low pressure side of the reducing valve. As previously mentioned, 15 lb. is the maximum pressure that the fire extinguisher will stand; it is therefore important to include the gage as a matter of precaution.



General Arrangement of Apparatus

How Belt Slipping Was Prevented

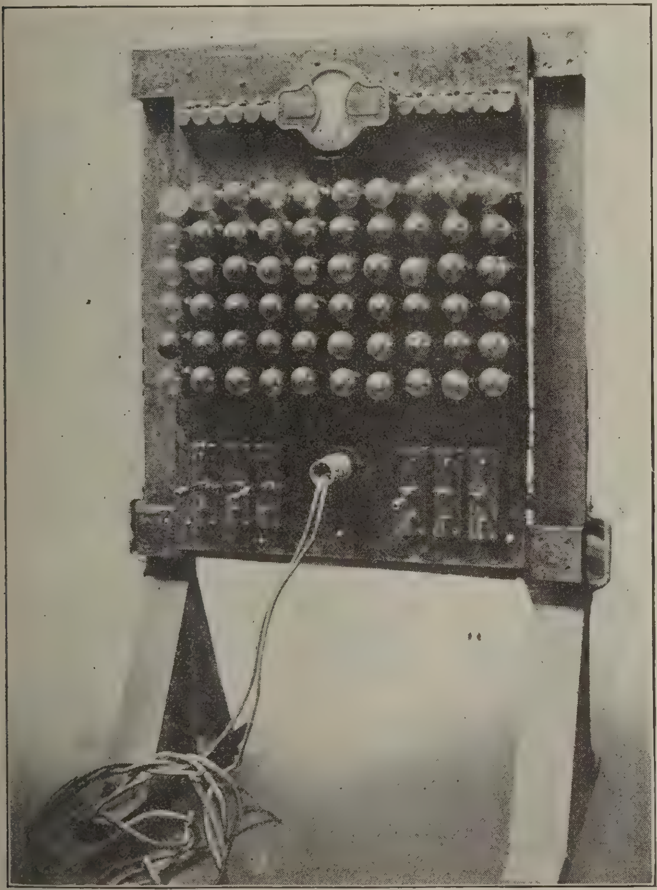
By A. R. Wicklander, Electrical Foreman
Chicago & Western Indiana

Some months ago the Chicago & Eastern Illinois changed the axle and generator pulleys on all of its cars equipped with safety F-1 equipment. It was found with the old 5-in. pulleys on the armature shaft, and 17-in. pulleys on the axle, that the belt slipped after the equipment reached cut-in speed, and would not take care of the load properly. The trouble was more pronounced in winter than at other times. This was probably due to the belt being less pliable and because the equipment had to operate under more severe conditions. To overcome this difficulty a change in the size of both pulleys was made. A Consolidated type "A" pulley, 8 in. in diameter was used on the armature shaft and a 21-in. standard pulley on the axle. In making this change it was necessary to rebore the armature pulley to fit the armature shaft. This rearrangement changed the ratio somewhat so that, other things being equal, the cut-in speed was slightly higher. The change in ratio, however, was not done purposely; if pulleys had been available that would have maintained the same ratio they would have been used. But even with the change that was made the results were especially beneficial in regard to the belt slippage and the equipment was able to take care of the load. The belts proved to give a much greater mileage and a greatly decreased number of failures in car lighting was the result.

A Portable Lamp Load for Battery Charging Plant

By William Tibbots, Electrical Foreman
Chicago, Rock Island & Pacific

A convenient load for discharging individual sets of car lighting storage battery, which for any reason may require a load test being made before the cells are returned to service, consists of a bank of lamps mounted on a portable rack, as shown in the illustration. The arrangement shown here has been used for several months with entire satisfaction at the Chicago, Rock Island & Pacific charging plant at Chicago.



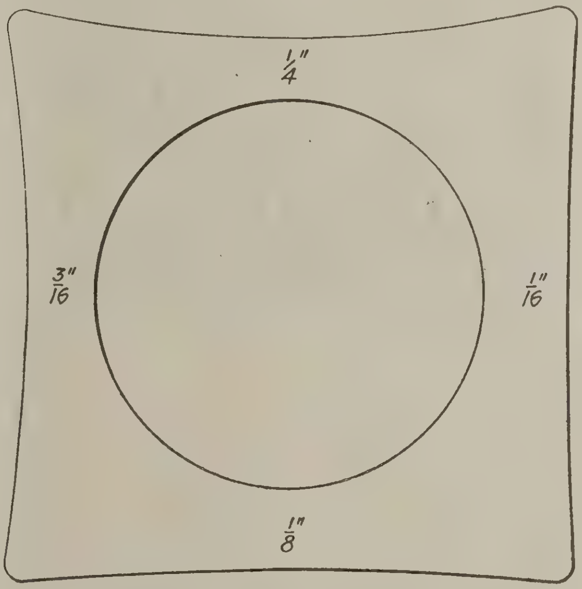
Portable Rack Supporting Bank of Lamps

Sixty 32-volt carbon lamps are used for the load. These are divided into 6 circuits of 10 lamps each, and single pole knife switches are provided for controlling the individual circuits. Each circuit is fused for protection purposes, and a single plug receptacle is provided near the lower center portion of the board for connecting the battery under test to the load. A Weston combination volt-ammeter mounted near the top of the board provides a means of determining the voltage and amperage during discharge. Ordinarily the load is regulated to 40 amperes. This portable lamp rack consists mainly of a wood frame mounted on casters so that it can be moved about the battery room. The lamp rack itself contains 60 porcelain keyless sockets, arranged in 6 horizontal rows with 10 sockets in each row. The entire frame and the sockets are painted with a heavy coat of P. & B. paint to protect the equipment from the acid fumes.

It will be appreciated that by constant use equipment of this kind in a large battery room will depreciate more or less because of the effect of acid on the metal and wood parts. However, during a period of about six months this board has received but little attention and has been in constant daily use during this time. The equipment should now be repainted, and with a few minor repairs it would be in just as good shape as when originally put in service.

A Gage for Pulley Crown

It is desirable to recrown the pulleys of car lighting generators when they have been worn down below an established standard. In order to check up the wear on pulley crowns so as to determine when they should be removed from service, the Norfolk and Western makes use of a gage shown in the illustration. This gage is stamped out from a piece of flat metal. It has a large circular opening in the middle and the four sides are made with curvatures corresponding to various heights of pulley crowns. By applying this gage to the face of the pulley it is immediately evident to what extent the pulley is worn and whether or not recrowning is necessary.

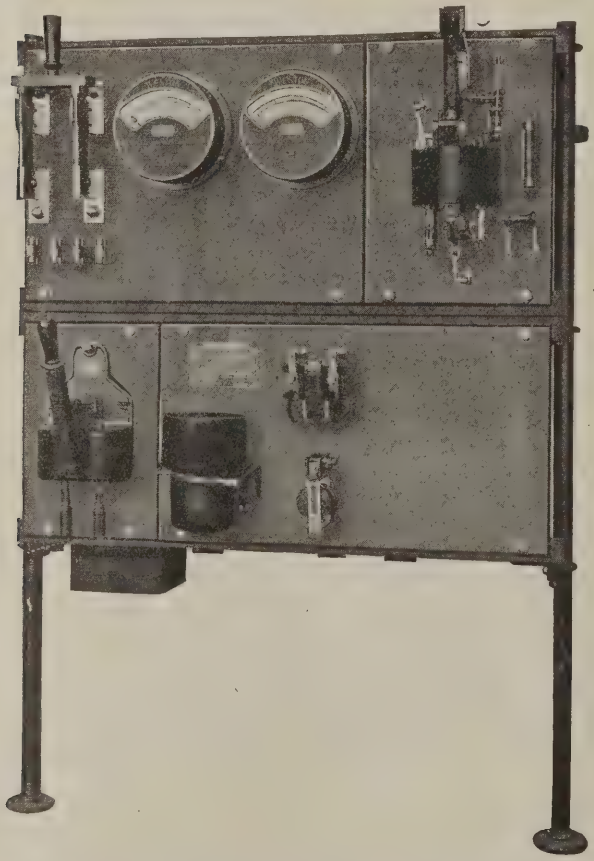


By Applying this Gage to the Pulley Face the Wear Is Readily Determined

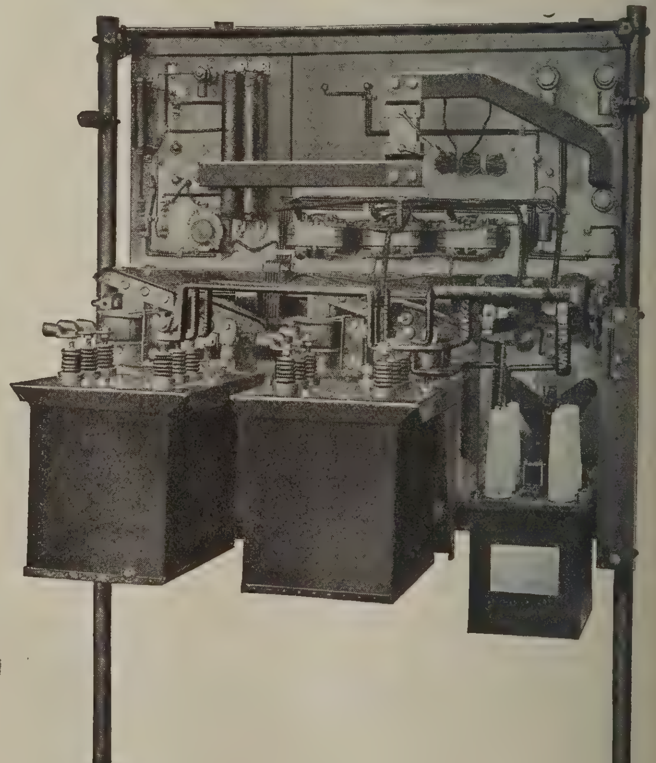
NEW DEVICES

Automatic Control Panel for Motor-Generator Sets

In mines and other places where the direct current supply is obtained from a motor-generator set, it is frequently advantageous to control the power equipment from some remote point, thus eliminating the necessity of an attendant at the switchboard. Several mines are using with their motor-generator sets an automatic control panel, shown in the illustrations, which has all the protective features used in the small modern switchboard and may be controlled from any remote point by means of an ordinary snap switch.



Switchboard for Automatically Controlling Motor-Generator Sets From Remote Points



Rear View of Board Showing A. C. Oil Switches and Circuit Breaker

This automatic equipment, which is manufactured by the Cutler-Hammer Manufacturing Company of Milwaukee, Wis., consists of the necessary circuit breakers, switches, relays, fuses and recording instruments mounted on slate panels carried on a floor type frame. The primary equipment of the control panel, shown in the illustrations, consists of a hand operated oil circuit breaker provided with inverse time overload attachments, a phase failure and phase reversal relay and an automatic starter of the auto-transformer type. This is to be used with induction motors, but the same general equipment with a few slight changes can be used with motors of the synchronous type. On the direct current side a knife switch, voltmeter and ammeter with the necessary fuses and an automatic reclosing circuit breaker are provided.

With the remote control switch "on," the controller may be operated by merely closing the main line oil circuit breaker, or the breaker may be left closed and the equipment operated by means of the remote control switch. The closing of the main circuit breaker effects the closing of the phase failure and reversal relay, unless one or more of the phases are open or reversed, in which case the abnormal condition must be removed from the line before the relay will close. This relay has also the characteristics of a voltage relay, so the equipment will not operate if the line voltage is very low. After the relay closes, the automatic starter connects the motor through an oil switch to the low-voltage taps of an autotransformer. When the equipment has come up to speed, the oil switch opens and a second oil switch connects the motor directly to the supply line, at the same time completing a circuit to the closing coil of the automatic reclosing circuit breaker, which immediately closes, establishing the generator voltage on the direct current feeders. In case of an overload on the direct current side, the circuit breaker opens and recloses when the overload is removed. The oil switches used on this equipment consist of an operating magnet of the clapper type which is mounted on the supporting frame of the switch and drives the switch mechanism by means of a connecting rod extending through the top of the case. Both the stationary and moving contacts of the switch are carried on square insulated shafts and are easily accessible.

These control panels can be furnished in different capacities up to 300 kw. and, when so desired, can be rebuilt for operating two motor-generator sets in parallel.

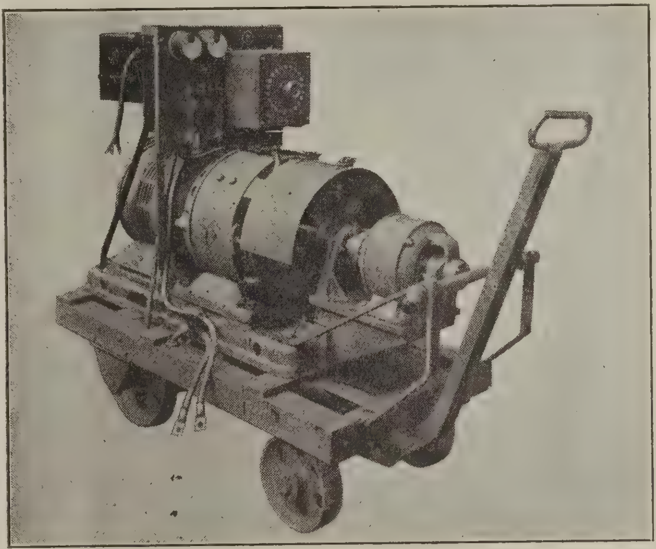
Single-Operator Electric-Welding Equipment

The single-operator electric arc-welding equipment, manufactured by the Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa., is claimed to be exceptionally efficient because the generator operates at arc voltage and no resistance is used in circuit with the arc. The generator is designed to inherently stabilize the arc, thereby eliminating the necessity for providing automatic moving devices such as relays, solenoid control resistors, etc. These not only increase the cost of investment and maintenance, but may not be quick enough in action to follow the instantaneous changes of the arc circuit. The generator of the set has a rated capacity of 175 amperes, and is provided with commutating poles and an exceptionally long commutator which enables it to carry the momentary overload at the instant of striking the arc without special overload protection.

The design of the control is such that very close adjustment of current may be easily and quickly made, and once made the amount of current at the weld will remain fixed within close limits until changed by the operator. There are 21 steps provided from 50 to 225 amperes. This gives a current regulation of less than 9 amperes per step which makes it much easier for a welder to do vertical or overhead work often encountered in railroad shops. Due to the special design of the generator and its exciter, it is unusually easy for the operator to strike and maintain the arc. Although the generator is strictly a short-arc machine, the arc produced is tenacious and causes the deposited metal to penetrate deeply into the work. These features are extremely desirable as they make it easier for a new operator to learn to do welding work and enable experienced welders to accomplish more in a working day.

The generator is mounted on a common shaft and bed-plate with the motor. A pedestal bearing is supplied on the commutator end which carries a bracket for supporting the exciter. The latter is coupled to the common shaft of the set by means of a special coupling. Motors can be supplied for either direct or alternating current circuits. Where an alternating current motor is used, leads are brought outside the motor frame for connecting for either 220 or 440 volt circuits. An electrician can change these connections in a few minutes' time. This feature is particularly desirable on portable outfits which may be moved from one shop to another, having a supply circuit of different voltages. Ball bearings are used on the single operator motor generator set.

Where the equipment is required for portable service, the motor generator set with the control panel is mounted on a fabricated steel truck, equipped with roller bearing wheels. The portable equipment can be easily hauled about the shop or yards by one man. Suitable plugs and receptacles for three-phase, three-wire or two-phase, four-wire, alternating current motors allow the set to be quickly and conveniently connected to the supply circuit at any desirable point. Only one plug is required for the motor, but the number of receptacles required depends upon the number of points at which it is desired to do welding work. These plugs and receptacles are supplied on special orders.


Portable, Single-Operator, Arc Welding Outfit

Control for the single operator equipment consists of a small ebony asbestos panel, mounted upon angle-iron framework. The field rheostat for regulating the welding current, voltmeter, ammeter and two-pole knife switch are mounted upon the panel. The motor generators are supplied in capacities of 300, 500, 750 and 1,000 amperes and are of standard Westinghouse design and construction. The generator is compound wound, flat compounded, i. e., it delivers 60 volts at no-load and also at full-load.

The motor and generator are assembled on a common shaft and mounted compactly on a bedplate and the 300-ampere capacity sets can be supplied either portable or stationary. The sets of capacity above 300 amperes are usually used as stationary sets. Sets of 500-ampere capacity are frequently arranged for portable service but are more readily handled by means of a crane than by mounting on a truck.

In using the multiple operator equipment each operator is provided with a separate control or outlet panel so that each may take current from the same generator without interference. For convenience, multiple operator equipments are divided into class 1 and class 2 equipments, depending upon the type of control supplied. The class 1 equipment has the main control panel arranged for the control of the generator and one welding circuit. The panel is made up of a single section upon which are mounted indicating instruments, protective apparatus and switches for adjusting the welding current. If additional circuits are required it is necessary to use separate outlet panels. The class 2 equipment has a main panel similar to class 1 except that it controls the generator only and separate outlets are used for all operators.

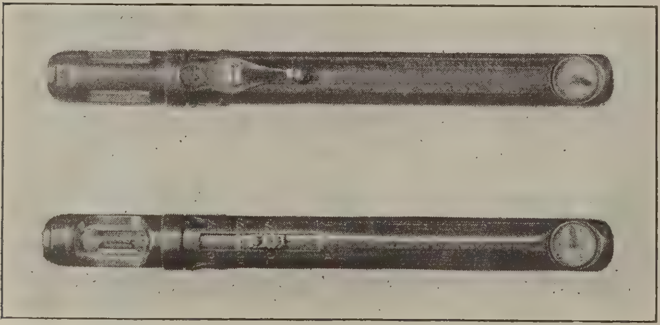
Each outlet panel consists of a slate panel on which is mounted a circuit breaker, line switch and the necessary single pole resistance adjusting switches for regulating the heat at the arc by varying the amount of current supplied. These outlet panels may be supplied for either metal or graphite electrode welding or both and may be operated simultaneously and independently of each other, the only limit being the capacity of the generator.

A metal or graphite electrode holder is supplied with each welding panel, according to the work for which the panel is designed. The holders are of light weight, well balanced and so designed that they may be used continuously without overheating. Hoods or shields, provided with colored lenses, are supplied for the protection of the operator.

Tester and Trouble Locator

A small instrument known as the "4 in 1" tester and trouble locator has recently been placed on the market by C. W. Eisenmann, Nebraska City, Nebr.

The inventor claims that with this device grounds, shorts and crosses in wiring can be quickly and accurately located without cutting or disconnecting any of the wires. Trouble developing in motors or generators may be readily located, as well as grounds occurring inside iron conduit. The instrument may be used like an exploring coil in weak magnetic fields, while in strong fields it acts as an a. c. galvanometer. In addition, the testor may be used as a polarity indicator, a frequency meter and an a. c. detector. It is equipped with a clip and may be carried in the pocket like a pencil.

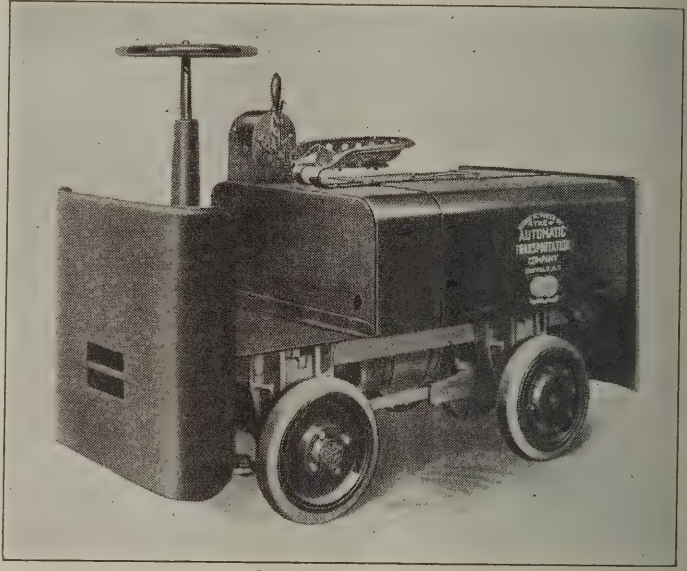


Two Views of the "4 in 1" Tester

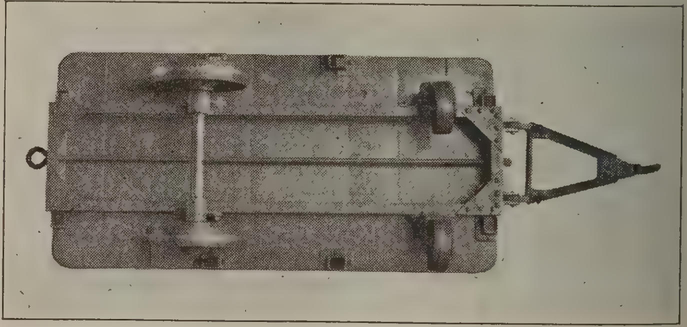
Tractors and Trailers

A new heavy and extra powerful type of electric tractor and a steel underframe trailer are offered by the Transportation Engineering Corporation, New York. They are manufactured by the Automatic Transportation Company, Buffalo, N. Y.

The tractor, which is known as Automatic Type M, is designed to meet the demand for a heavy duty tractor and is recommended for service in railroad shops and passenger stations. It is equipped with heavy cast steel bumper plates on both ends to facilitate the pushing of trailers and to provide extra protection to the machine and the operator. A 3½ hp., 1700 r.p.m. motor suspended on springs drives the tractor through a single reduction worm and wheel. All power transmitting parts are mounted in an oil-tight, dust-proof housing. This tractor may be equipped with either a 42 cell, A-8 Edison battery or with a 24 cell, M V Y Exide Ironclad battery.



Type M "Automatic" Tractor



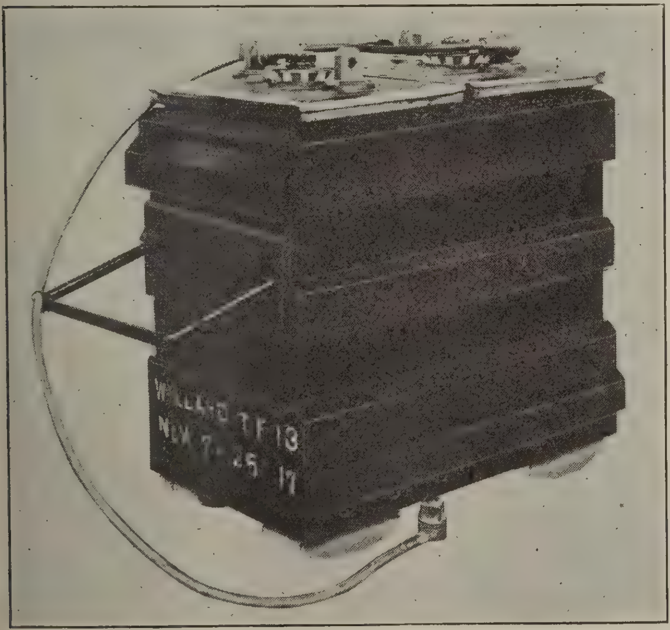
Botton View of "Automatic" Steel Under-Frame Trailer

The controller is of the metal drum type and provides three speeds forward and three reverse with a maximum speed of from 5 to 6 miles an hour. The normal draw bar pull is 800 lb. while the ultimate is 2,000 lb. The total weight of the tractor without the battery is 2,420 lb. It is made with either two or four-wheel drive, two or four-wheel steer and with sixteen or twenty-inch rubber tired wheels.

The trailer is of the steel underframe, caster type. The steel underframe is applied to the trailer construction for the same reasons which have led railroad mechanical men to adopt the steel underframe in passenger and freight car construction. This trailer is, therefore, adapted to the severe service met with in railroad shops and terminals. Another distinctive feature of the Automatic trailer is the special heavy duty caster with which it is equipped. This caster is not only generously proportioned in order to withstand severe shocks under heavy load, but it is provided with both roller side thrust and ball vertical thrust bearings insuring practically frictionless operation. The rear axle is also equipped with grease packed roller bearings. The trailer is provided with a special built up coupler hook, so designed and assembled that important parts such as hook and hinge castings can easily be replaced when necessary.

Combination Storage Battery

A combination storage battery, designed during the war when lead costs were high, has been developed by the Willard Storage Battery Company, Cleveland, Ohio. This battery is of exceptionally light weight, being 30 per cent lighter than the straight Plante battery of the same capacity manufactured by the Willard Company. A proportionately smaller space, therefore, is required.



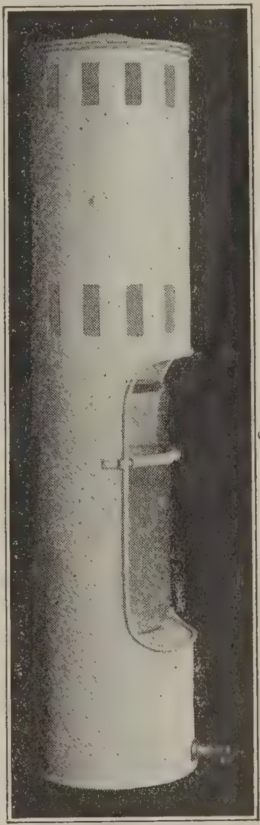
Willard Combination Storage Battery

The negative battery plates are of bi-plane construction, the leaves on either side being cut to the center of the plate at right angles to each other. This type of negative plate has been used for ten years in railway work on a few sets of batteries and for three years on a large number of batteries. The estimated life of the plate is 15 to 20 years.

The positive plates are of the pasted type, made of the same material as the Willard automobile starting battery plates except that they are considerably thicker. The battery has hard rubber covers and porcelain vent plugs. It is assembled either in rubber jars or lead linings. Rubber jars are exhibited which are made to the following specifications: 15 per cent elongation, 5,000 lb. per sq. in. tensile strength. The battery is made in capacities of 300 and 400 ampere hours.

Electric Water Cooler

The Safety Car Heating & Lighting Company, New York, has produced an electric water cooler so designed that it can be applied to an ordinary car cooler or be used in the space now occupied by one. No ice is required, the machine being operated by a motor.



Two Gallon Electric Water Cooler

The lower part of the cooler is of the well-known inverted bottle type except that there is a coil of pipe and a thermostat in the small tank below the bottle. The bottle has a capacity of two gallons. Above the bottle is a radiator and an electric motor which drives a small compressor and a fan. The system contains a small quantity of refrigerating medium.

When the temperature of the water in the tank rises to 45 deg. the thermostat causes an automatic switch to close, which starts the motor, compressing the refrigerant to a liquid state in the radiator while the fan blowing air over the radiator, carries away the heat of compression. The liquefied gas then flows to the cooling coil in the tank where it is expanded, absorbing heat from the water around the coil. The expanded gas then goes again to the compressor and the cycle is repeated. The motor is stopped by the thermostat when the tem- of the water falls to 40 deg.

The complete outfit is contained in a cylinder 3 ft. 9 in. long by 10 in. in diameter. The device can be operated from any source of electric power for which fractional horsepower motors are designed.

Collapsible Canvas Tool Bag for Linemen

The Industrial Products Company, Philadelphia, has put on the market a canvas tool bag for use in hoisting tools, paint and other implements or supplies. The bag is made with no metal parts which can come into contact with the current, as the sides are of canvas, the bottom is of wood and the handle is of rope. The manufacturers have designed it to hold tools and materials which, if not properly taken care of, may be a menace to those below.

General News Section

The Cooper Hewitt Electric Company, Hoboken, N. J., has recently purchased property adjoining its plant which will eventually double its present floor space.

A new supply sub-warehouse of the Western Electric Company, Incorporated, New York, has been opened in Youngstown, Ohio, at 930 West Rayan avenue. The new office reports to the Pittsburgh distributing house. **C. A. Strouss** is in charge of sales and **H. B. Bergmann** in charge of stores.

Fairbanks-Morse Pension Fund. The trustees' report for 1919 shows 8 members pensioned, death benefits of $11,675, and net resources of $505,000 practically all invested in high grade bonds. The Fund was established on January 1, 1917, and at the close of 1919 had 1,139 contributing members.

The Economy Fuse & Mfg. Co. of Chicago, manufacturers of Economy renewable fuses, announce the appointment of **F. L. Easton** as district sales-manager of its Denver office, 205 Commonwealth building, Denver, Colorado. Mr. Easton succeeds **R. M. Olsen,** who resigned recently. Mr. Easton formerly was connected with the Economy Fuse & Mfg. Co., but more recently has been doing sales promotion work for the Gates Rubber Company.

D. T. Laylin has been apointed sales manager of the **Adams-Bagnall Electric Company,** Cleveland, Ohio. Mr. Laylin became associated with the electrical business in 1905, when he entered the service of the Western Electric Company. After being in charge of the electrical sales and shop departments of the Strong-Carlisle-Hammond Company of Cleveland for five years, he became electrical engineer of the Standard Parts Company of Cleveland.

Equipment for an electric ferryboat has been ordered from the Westinghouse Electric & Mfg. Co. When completed the boat will operate across the Delaware River between Philadelphia and Camden, N. J. The control feature is unique in that the boat will not only be steered from the pilot house but the electric propulsion will be operated also by a controller located at this point. This new departure in ferry boat operation it is believed will be a decided advantage when maneuvering the boat in congested river traffic.

The electrically propelled battleship U. S. S. Tennessee, which went into commission on June 3, is the most powerful fighting vessel in the world today. She is 625 ft long, has a beam of 98 ft. and displaces 32,500 tons. Her main battery consists of twelve 14-in. guns, and she is protected by a belt of armor 14 in. thick. Her main engines consist of two Westinghouse turbine-generators, rated at 15,000 kva. each, and each of the four propellers is driven by an 8,000-hp. Westinghouse motor. Her maximum speed with full power is 21 knots.

The Western Electric Company, Inc., New York City, announces the construction of a new building at 395 Hudson Street. The building which will be partly an eleven story office building and warehouse and partly a five story and basement warehouse, is said to be the largest concrete building ever erected in Manhattan. It will occupy the entire block surrounded by Hudson, West Hudson, Greenwich and Clarkson Streets. It is expected that the building will be completed by May, 1921. The cost of the whole operation will involve nearly $3,000,000.

The Roller-Smith Company, New York, announces the appointment of **Hammond D. Baker** as manager of its Detroit office at 1202 Majestic building. Mr. Baker is a graduate of the course in electrical engineering at the Alabama Polytechnic Institute. Soon after his graduation he entered the government aviation service and was sent to the aviation school for radio officers at Columbia University, New York, being commissioned as second lieutenant on completion of the course. Later he became associated with the United Motors Corporation as technical traveling representative and very recently was engaged by the Hoskins Manufacturing Company of Detroit in its sales department, from which position he resigned to accept his present position.

New York Electrical Society Elects Officers

The annual meeting of the New York Electrical Society for the election of officers was held on June 8, at 4 p. m. in the Engineering Societies Building, New York. The minutes of the previous meeting were dispensed with, but the reports of the several committees were read. The records show that the membership committee has done exceptionally good work, the total membership of the society now reaching 845. The treasurer's report, which was corroborated by the report of the financial committee, showed a deficit of a little more than two hundred dollars. It was stated, however, that this was caused by the tardiness of some of the members in paying their dues, and that if all dues in arrears were paid up there would be a balance in the treasury of several hundred dollars.

The following nominations were submitted by the nominating committee and were unanimously elected: For president, W. N. Dickinson; for vice-presidents, Ernest W. Muller, Charles E. Speirs, J. M. Buchanan; for secretary, George H. Guy; for treasurer, Thomas F. Honahan.

Three vice-presidents who were elected in 1919 to serve for two years were: C. D. Gray, L. G. Nilson, John S. Timmons.

A vote of thanks was taken as a token of appreciation of the excellent work performed by the retiring officers.

Electrification in Belgium

The *Electrical Review,* London, reports that at a recent general meeting of a large Belgian manufacturing concern, the Ateliers de Constructions Electriques de Charleroi, the chairman stated that the company was perfectly equipped for eventually dealing with orders for plants for the electrification of the national railways, and in this connection the company has supplied first class plants to its subsidiary at Jeumont for the electric line of the Midi Railway in France. However, the directors have estimated that the time is not opportune to think of general electrification of the Belgian railroad system due to reconstruction conditions. There are certain trunk lines which call for electrification, as, for instance, that between Brussels and Antwerp, which has been under discussion for twenty years.

Compensation of Engineers

The classification and compensation committee of Engineering Council has addressed a letter to the secretaries of approximately 100 national and local engineering and other technical societies, requesting formal indorsement or expression of opinion relative to the classification adopted by Engineering Council for grading the compensation of engineers. The committee has been reorganized and is now made up as follows: Arthur S. Tuttle, chairman, deputy chief engineer, Board of Estimate and Apportionment, New York City; Charles Whiting Baker, secretary, consulting engineer, New York City; Frederick W. Cappelen, city engineer, Minneapolis, Minn.; Philip P. Farley, consulting engineer, Brooklyn, N. Y.; O. C. Merrill, chief engineer, Forest Service, Washington, D. C.; C. A. Morse, chief engineer, Chicago, Rock Island & Pacific, Chicago; M. M. O'Shaughnessy, city engineer, San Francisco, Cal.; R. S. Parsons, general manager, Erie Railroad, New York City, and Edmund I. Mitchell, assistant secretary, New York City.

Non-Stop Flight Omaha to Lancaster

On Sunday, June 27, a Larsen all-metal aeroplane was flown from Omaha, Neb., to a point twenty miles east of Lancaster, Pa., in bout eleven hours, without a stop; estimated distance 1,200 miles. The distance by railroad is about 1,270 miles. About 105 gallons of gasoline were used. The aviator had intended to fly to New York City, but was obliged to land because of a hazy atmosphere.

A. I. E. E. and A. S. M. E. to Combine Forces

Plans have been made for holding a series of joint meetings of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers. The objects of the joint meetings are to secure a strong program and, as the war interrupted interest in normal engineering progress, to create a new interest in old problems which now require revised consideration under existing conditions. In general the subjects selected for these meetings will come under the following classifications: Marine engineering, engineering education, industrial installations, power generation, steam railroad electrification and industrial relations. It is intended to hold the first meeting in October, on a date to be announced later.

PERSONALS

Norman W. Rose has been appointed electrical engineer of the Duluth & Iron Range, succeeding **A. M. Frazee,** effective June 25.

N. W. McCallum, electrical supervisor bridges and buildings on the New York Central, with headquarters at New York, has been appointed division engineer at Oswego, N. Y., succeeding S. E. Armstrong.

George L. Burwell, electrician apprentice on the St. Louis-San Francisco, has been transferred from Kansas City, Mo., to the West Shop, Springfield, Mo., vice **Louis J. Bellew,** resigned, and **William A. Bruce,** succeeds Mr. Burwell at Kansas City. **Charles P. Bowler,** roundhouse laborer at Springfield, Mo., has been promoted to electrician apprentice at the same place to succeed **Othel G. Scarbrough,** transferred to the West Shop in place of **Richard D. Guilliams,** who has been granted a leave of absence on account of illness.

D. C. Wilson

Don C. Wilson has been appointed assistant sales manager in charge of the railroad department of the **Edison Storage Battery Company,** Orange, N. J., with office at Room 904, 23 West Forty-third street, New York. Mr. Wilson was educated in the public schools of Broken Bow, Neb., and the Nebraska State University, completing his course in electrical engineering in 1907, after which he was engaged in electrical work in various capacities with the Stone & Webster Construction Company, at Seattle; the United States Navy Yard, Bremerton; the Pacific Gas & Electric Company, Los Angeles; the Independent Telephone Company, Omaha; the Union Pacific Railroad, Omaha; the Central of Georgia, Savannah; the Delco Light Company, Chattanooga, and the Edison Storage Battery Company.

The St. Louis-San Francisco Railroad announces the following appointments of electricians, first class: **R. C. Horn,** succeeding **Hugh W. Brown,** resigned, and **Joe L. Nutty,** succeeding **William W. Thompson** resigned, both at Oklahoma City, Okla. **Harry H. Finch** at Springfield, Mo., succeeding **George W. Weitnauer,** who has been transferred to the St. Louis, San Francisco & Texas at Fort Worth, Texas. **Jay C. Hare** at Fort Scott, Kan., succeeding **John R. Frank,** transferred to the West Shop at Springfield, Mo., to succeed **A. A. Jertberg,** who has been promoted to armature winder.

OBITUARY

Axel Carl Ekstrom, consulting electrical engineer, of the Delaware and Hudson Company and its allied lines, died at his home in Ballston Spa, New York.

Carl P. Berger, president of the Irvington Varnish & Insulator Company, died on June 15. Mr. Berger was one of the pioneers in the manufacture of insulation. He invented special machinery for varnishing cambric silks and paper in continuous rolls, greatly reducing the cost of manufacture and at the same time perfecting the product.

C. Blizard

Charles Blizard, third vice-president of the **Electric Storage Battery Company,** died on Saturday, June 12. He was born at Stevens Point, Wis., in 1864, and was educated in the east, graduating from the Brooklyn Polytechnic Institute. In October, 1893, he became associated with the Electric Storage Battery Company and was in the service of the company a total of 27 years. He was at first manager of the New York office and in 1900 he was moved to the home office in Philadelphia in charge of sales. In April, 1906, he was made third vice-president, which position he retained until the time of his death. Mr. Blizard was a prominent figure at conventions of Central Lighting and Power Companies, and for years served on the exhibition committee. He was also an active member of the Electric Vehicle Association, serving on various committees, and he later continued his activities in the electric vehicle section of the National Electric Light Association. He was a member of the board of governors, chairman of the finance committee of the Associated Manufacturers of Electrical Supplies, and was his company's official representative in the Motor Accessory Manufacturers' Association.

TRADE PUBLICATIONS

Sprague Electric Works of the General Electric Company, New York, has recently issued its bulletin No 44553.1 illustrating and describing the Sprague flexible steel armored hose.

The Ohio Brass Company, Mansfield, Ohio, has issued a pamphlet on "O-B Electric Arc-Weld Bonds," showing specifications for every clause of welding steel to steel with steel.

The Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has issued a two-color pamphlet, "Recent Notable Achievements," including illustrations and descriptions of transportation facilities on land and on sea, also of mammoth power generating units.

Belt Fasteners.—The Crescent Belt Fastener Company, New York, has published a new handbook illustrating Crescent belt fasteners in use on many different kinds of belting and under different conditions and giving full data regarding their use.

The Ways and Means of Better Insulator Practice is the name of a 16-page booklet which is published by R. Thomas & Son Company, of East Liverpool, Ohio. The pamphlet is devoted to the illustration of the Thomas Linktype Hewlett insulator, which is designed primarily for high tension transmission lines.

The Benjamin Electric Manufacturing Company, Chicago, is distributing a large mailing piece, the title of which is "Cabbages and Kings." The folder contains a letter addressed to the agents who sell Benjamin equipment and also contains a proof of the advertising copy running in current magazines.

The Fafnir Bearing Company, New Britain, Conn., is distributing its booklet No. 20, containing 70 pages illustrating the various types of ball bearings manufactured by this company and the methods of adopting them to machine tools of all kinds. A portion of the book shows the application of ball bearings to a number of sizes of electric motors.

American Metal Products Company, Brooklyn, N. Y, has recently issued a small pamphlet illustrating and describing a number of the specialties which this company manufactures. Among these specialties are several types of receptacle boxes with self-closing spring covers, arranged with gaskets in such a way as to be weatherproof. Another specialty is the universal gage lamp for use on locomotives.

Transportation Engineering Corporation, New York and Chicago, is distributing an 8-page booklet entitled "Wanamaker Coated Electrodes for Arc Welding." The booklet contains a number of photographs chiefly showing railroad material that has been welded with these electrodes. The last page of the pamphlet is devoted to a description of welding accessories including electrode holders, shields, handles and goggles.

The Electric Storage Battery Company, Philadelphia, Pa., is distributing its news bulletin No. 178 and catalogue "CR." The bulletin is devoted to descriptions and illustrations of various car lighting "chloride" battery equipment, especial emphasis being placed upon "Giant" rubber jars. The catalogue is an 8-page illustrated booklet showing the different parts of storage batteries used in car lighting. All of the various sundries and battery parts for the "chloride accumulators" are listed in this booklet.

The Electric Service Supplies Company, Philadelphia, New York and Chicago, has issued a new 608-page catalogue known as Catalogue No. 6 which lists and illustrates broad lines of material for Steam Railroads, Mines and other large industrial organizations. Some of the most prominent lines include this company's Golden Glow steam and mine locomotive headlights, marine searchlights and projectors, Keystone turbogenerators and Keystone headlight switches. Keystone contact rail material for cranes and haulage systems, Peerless armature repair machinery and Segur coil winding machinery are also shown.

Railway Electrical Engineer

olume 11 August, 1920 Number 8

THE RECENT WAGE AWARD

The recent wage award decision handed down by the ilroad Labor Board has been the cause of a great deal discussion not only on the part of the men affected, t by the general public as well. In the final analysis, e public is the source from which all wages are forth-ming, and it is safe to say that it will not take kindly any higher freight and passenger rates than have just en obtained by the roads.

Railroad men today are exceedingly well paid com-red with corresponding work in other lines of en-avor. The fact that the occupation of the railroad ployee is comparatively steady makes railroad employ-nt altogether desirable. Furthermore, if this con-tion is true today how very much better off will the ilroader be a few years hence, when normal prices are ain restored; for while there is every reason to expect drop in prices in many commodities when once the pply has caught up with the demand, there is very little elihood that the wages of railroad men will meet with corresponding reduction. This condition will result in acing railroad employment in an enviable position, but may be well to keep in mind at the same time the qual-t of the railroad labor will be very much improved. e railroad man in the future will be quite a different dividual from many who are in the business today, and e fellow who is neglecting to make the most of his op-rtunities will be weeded out and discarded.

THE IMPORTANCE OF ILLUMINATION

There is perhaps no other place where it is more mmon to slight the maintenance of shop lighting quipment than on the railroads. A shop lighting sys-m not properly cared for may easily fall off fifty r cent in efficiency within a few weeks. The de-ease in illumination from day to day is so gradual at the total change in the intensity of illumination not arrived at abruptly but rather by successive ages, so that it is not surprising to find a shop where e illumination has been very greatly reduced in ite of the fact that an excellent lighting system and roper lighting units are in use. The decrease in ficiency is due almost exclusively to the thin film of ust which settles upon the surfaces of the lighting nit. If this is not removed at frequent intervals ventually the accumulation becomes so great as to riously interfere with the dispersement of the light om the unit. Not only is the efficiency of the light-g system impaired, but it has been proved time and time again that poor illumination is directly responsible for decreased shop output.

In view of these facts it is apparent that there is wisdom in providing for shop lighting maintenance. The problem is not one that is difficult of solution; it narrows down to merely making some reliable employee responsible for the maintenance of the lighting system. Clothe him with sufficient authority to enable him to get the work done, instruct him to wipe reflectors and lamps once a week; to wash them with soap and water every third or fourth cleaning period; to fill the empty sockets; to replace burnt-out and blackened lamps; and to make sure that the voltage rating of the lamps is no higher than the voltage at the socket when the system is in use. This latter point is important, as a small reduction in voltage will cause a comparatively large reduction in candle power. If these suggestions are carried out there will be an increase in shop efficiency and the power consumed by the lamps will be available for useful illumination instead of merely heating ambient atmosphere.

THE FALL CONVENTION OF THE A. R. E. E.

The twelfth annual convention of the Association of the Railway Electrical Engineers will be held during the week of October 18, at Chicago. Specific information concerning the exact location together with a list of the reports to be presented will be given in the September issue of the *Railway Electrical Engineer.*

One of the most vital matters which probably will be discussed will be the question of the amalgamation of the Association of Railway Electrical Engineers with the American Railroad Association. This matter has been pending for a long time and the indications are that some definite action will be taken at the forthcoming convention. The question is one that has been uppermost in the minds of the members since the consolidation was first suggested at the October convention last year.

Since the convention a year ago the railroads have passed back into the hands of the original management. Such a transfer could not be made without its effect being felt in practically every department—the electrical department along with the others. It is up to each electrical engineer to see that he is present at the coming meetings. The opportunity to discuss electrical matters, both on the convention floor and with each other, is something which cannot find its equivalent in any amount of correspondence. Remember the date and be on hand.

ELECTRIC HEADLIGHT INSTRUCTIONS FOR ENGINEMEN

The enormous number of headlight equipments which have been placed on the locomotives of the various roads have added another problem to the already long list with which the electrical department has to contend. Some of the roads have placed the entire work of supervising the maintenance of headlight equipment under a chief inspector or supervisor. At the several division points are located headlight maintainers who report directly to this supervisor. It would seem that some such an arrangement would be decidedly advantageous, for on the majority of roads the number of headlight equipments varies from a few hundred up to several thousand, and the work involved in taking care of them will be of such magnitude as to warrant the appointment of a headlight supervisor who can give his entire attention to the matter of keeping down the maintenance cost.

The dual character of the equipment, involving, as it does, both steam and electrical features, has given rise to some uncertainty as to the manner in which the maintenance work should be carried on. Generally speaking, however, the amount of electrical work involved in the care of headlight equipment, cab lamps, classification lamps and marker lamps, is considerably greater than that required in the maintenance of the steam supply and the turbine. For this reason, it would seem practical that the work should be taken care of by men who are primarily electrical men.

The steam end of the equipment is practically a mechanical proposition and from the very nature of his experience it is something that the locomotive engineman would readily understand. Moreover, such troubles as might result in the steam end of the turbo-generator are more liable to be of a visual nature; that is, the cause for the trouble is more likely to be something which can be seen. It is therefore relatively a simple matter for the engineman to take care of the steam end of the equipment himself.

One road at least has placed a large portion of the burden of maintaining headlight equipment upon the enginemen. Small, vest-pocket, instruction books of fourteen pages have been distributed to the enginemen and they are required to make the necessary inspections themselves. While this, of course, does not eliminate entirely the inspection of an electrical man, it does aid materially in the maintenance of the equipment and reduces to a minimum the possibility of the failure of the equipment on the road. The little book mentioned contains much practical information which is presented in non-technical terms, so that it may be easily understood by any engineman. It would seem that such a practice would work out very satisfactorily in practically all cases. The amount of time consumed by any individual engineman in the inspection and care of his headlight equipment would be a minimum, whereas the total number of man hours saved would be a very large factor in keeping down the cost of headlight maintenance. Unless some steps are taken, such as have been mentioned, this factor will become a very heavy burden to the electrical department. The watchword of the roads, today, should be "Increased Efficiency"—and there is nothing that will produce this condition better than co-operation between the electrical department and the locomotive enginemen.

THE SWISS ELECTRIFICATION

Early in July the announcement was made that the Swiss Government was to float a twenty-five million dollar bond issue of twenty-year, eight per cent bonds, in the United States, the proceeds to be spent in this country for the gradual electrification of the railway systems of Switzerland. Owing to the light weight of Swiss railway equipment, the slow speeds at which it is operated, as well as the heavy grades and long tunnels peculiar to that country, there is probably very little to be learned that would be of benefit in planning the electrification of any American railroad system. The transmission lines in Switzerland operate at from fifteen to twenty-five cycles, whereas in this country the present tendency seems to indicate that sixty cycles will be generally used for transmission lines. Switzerland has been practically driven to take this step, owing to her inability to secure her customary supply of coal from Germany. On account of this curtailment of fuel the railroads were obliged to resort to wood, which, at the best, was unsatisfactory as well as expensive. The fact that the Swiss Government is willing to pay eight per cent, a high rate for a long term loan, is significant of the improvement which they expect to realize. It is evident that the United States is looked upon as a desirable place to purchase this material and the fact that the money is raised in this country overcomes the objection of the Swiss supply companies to sending money out of Switzerland and at the same time obviates the difficulties of the present exchange situation.

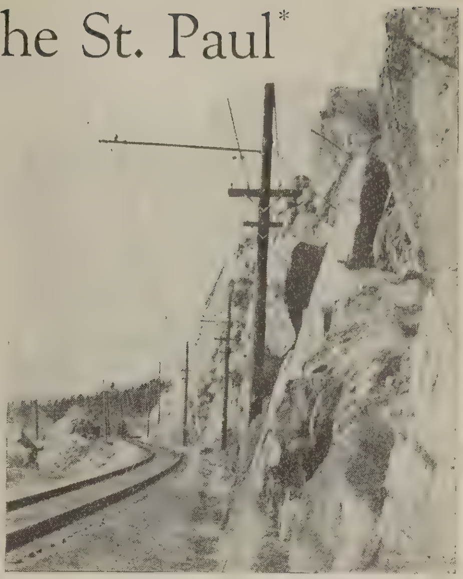
NECESSITY FOR WELDING SUPERVISION RECOGNIZED

In contrast with so many unsuccessful attempts to use arc welding it is refreshing to run across a man who is not an electrical arc welding man but who, while he possesses a knowledge of electrical work, recognizes the difference between the average electrical problems and those involved in the art of successful electric arc welding. In one of our large railroad repair shops a very extensive use of acetylene welding is made. This type of welding is well understood by the men in charge, and having been long in the field it has established a precedent which, for that particular shop, has become virtually standard practice. Under these conditions the bill for acetylene gas runs between four and six thousand dollars per month. As stated by the electrical man, the chief reason why more extensive use of electric arc welding is not made is because he recognizes the necessity for capable supervision of welding operators. While it is a matter of interesting conjecture how much of the acetylene gas cost could be saved by the installation of arc welding, it is a fact that unless proper supervision could be given to such an installation as our electrical friend fears would not be obtainable, it is far better that no extensive use of electric arc welding be made.

Power and Maintenance Costs on the St. Paul*

Operating Expenses on the Missoula and Rocky Mountain Divisions for 1919 Are Remarkably Low

By Reinier Beeukes
Electrical Engineer, Chicago, Milwaukee & St. Paul



A Bit of St. Paul Right of Way Showing Catenary Construction as Used on Curves.

POWER for the electrical operation of the Chicago, Milwaukee & St. Paul, between Harlowton, Mont., and Avery, Idaho, is delivered to the transmission system of the railway in the form of 100,000-volt, 3-phase, 60-cycle current. It is supplied under two separate contracts, one for the Rocky Mountain division, extending from Harlowton to Deer Lodge, and the other for the Missoula division, extending from Deer Lodge to Avery.

The power company's 100,000 transmission system is shown on the map, as are also the points of power delivery to the railway company and the latter's 100,000-volt transmission system. The railway transmission line of the Rocky Mountain division extends from Two Dot substation to the Morel substation, a distance of 184 miles, the former point being 12 miles from Harlowton, the eastern terminus of the division, and the latter point 17 miles from Deer Lodge, the western terminus. Power is delivered by the power company at the Two Dot, Josephine, Janney and Morel substations. The railway transmission line of the Missoula division extends from Gold Creek substation, 18½ miles from Deer Lodge, a distance of 180 miles, to the substation at Avery, the western terminus of the division.

Seven substations on each division are used to convert the 100,000-volt alternating current of the transmission line to the 3,000-volt direct current used for traction purposes. Each motor-generator consists of two 1,500-volt direct-current generators connected in series and driven by a 2,300-volt synchronous motor supplied from the substation high tension busses through a 3-phase, 100,000/2,300-volt transmission former and is guaranteed for a maximum five-minute overload of 200 per cent. The rated capacities of these stations are shown in Table I.

TABLE I—SUBSTATIONS AND SUBSTATION EQUIPMENT

Substations	Transformers	Motor-generators
ROCKY MOUNTAIN DIVISION		
Two Dot	2—2500 kva.	2—2000 kw.
Loweth	2—2500 kva.	2—2000 kw.
Josephine	2—2500 kva.	2—2000 kw.
Eustis	2—2500 kva.	2—2000 kw.
Piedmont	3—1900 kva.	3—1500 kw.
Janney	3—1900 kva.	3—1500 kw.
Morel	2—2500 kva.	2—2000 kw.
MISSOULA DIVISION		
Gold Creek	2—2500 kva.	2—2000 kw.
Ravenna	2—2500 kva.	2—2000 kw.
Primrose	2—2500 kva.	2—2000 kw.
Tariko	2—2500 kva.	2—2000 kw.
Drexel	2—2500 kva.	2—2000 kw.
East Portal	3—2500 kva.	3—2000 kw.
Avery	3—1900 kva.	3—1500 kw.

Contact and Return Wires

The contact wires of the trolley system consist for the main line of two No. 4/0 B. & S. grooved trolley wires flexibly supported side by side from a ½-in. steel catenary and tapered at intervals of about every thousand feet to a feeder or feeders which connect to the adjacent substation busses through switches and automatic circuit breakers. Over passing, industrial and similar tracks only a single 4/0 copper trolley wire is used. There is an insulated air gap in the trolley in front of each substation separating the trolley system west of the substation from that east of the substation; that is, portions east and west of the substations are fed, respectively, through separate feeder breakers. There is also an insulated air gap at the beginning and end of every passing track, so that by means of a section switch installed in the feeder at the gap the district between any two gaps may be isolated in case of trouble so as to permit operation up to the location of the open switches.

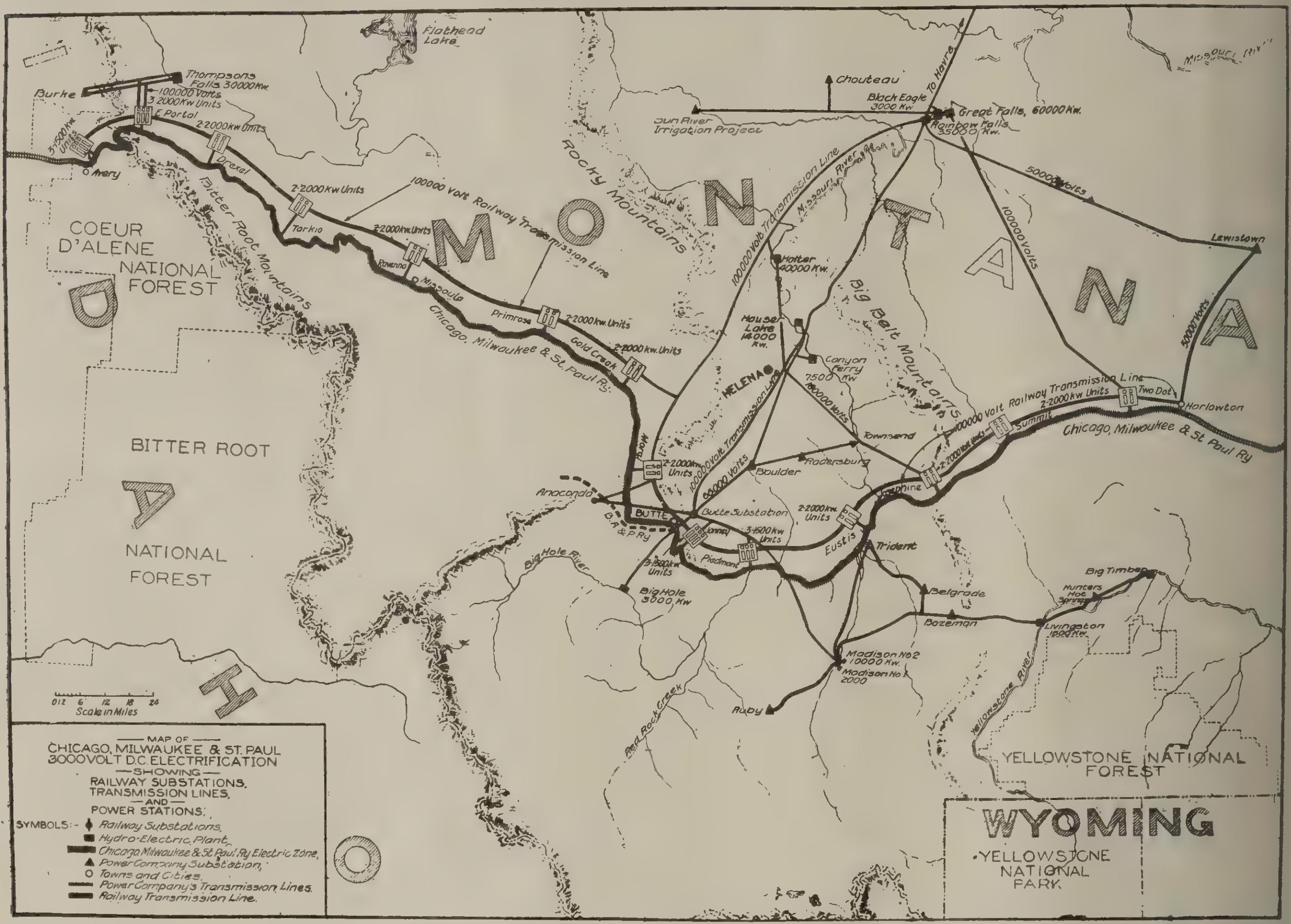
The return circuit consists of the 90-lb. running rails and, in general, of a 4/0 B. & S. copper supplementary negative wire which is run along the trolley poles and connected to the track at intervals averaging about 8,000 ft. through each alternate signal system reactance bond. This supplementary negative, however, is intended more as a safety measure to bridge open rail bonds than to increase the return circuit conductivity. However, on various feeder cutoffs on the mountain grades, where the conductivity of the positive circuit closely approaches that of the return circuit, one of the two feeders of the cutoff is in parallel with the running rails and is provided for the purpose of increasing the return circuit conductivity.

Power Demand is Controlled

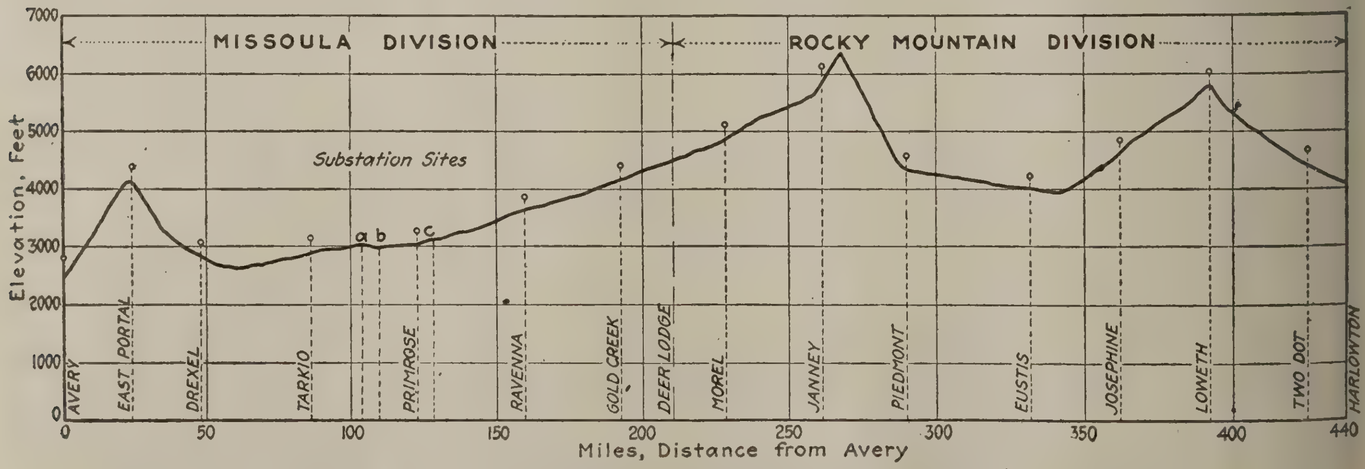
The terms of the power contracts are similar and each provides for a minimum payment on basis of a 60 per cent load factor. Where the load factor exceeds 60 per cent, payment is made on basis of the actual kilowatt hours consumed, the rate being 5.36 mills per kilowatt hour. The demand is controlled for each division by means of a so-called power indicating and limiting system which, on the Rocky Mountain division, was put into operation early in the year 1918 and on the Missoula division a few months ago. Briefly, this system is so arranged as to indicate and record at the despatcher's office at Deer Lodge the total kilowatts or demand being supplied in any instant by the power company and to prevent the maximum demand from exceeding a certain amount as determined by the "demand setting made by the despatcher," this limiting action being secured by lowering of the substation d.c. voltage and therefore of the train speeds.

---

*Abstract of a paper presented before the Pacific Coast Section of the American Institute of Electrical Engineers, Portland, Ore., July 22, 1920.



Rocky Mountain and Missoula Electrified Divisions of the St. Paul Showing Sub-Stations, Transmission Lines and Power Stations



Profile of Missoula and Rocky Mountain Electrified Divisions Showing Location of Sub-Stations

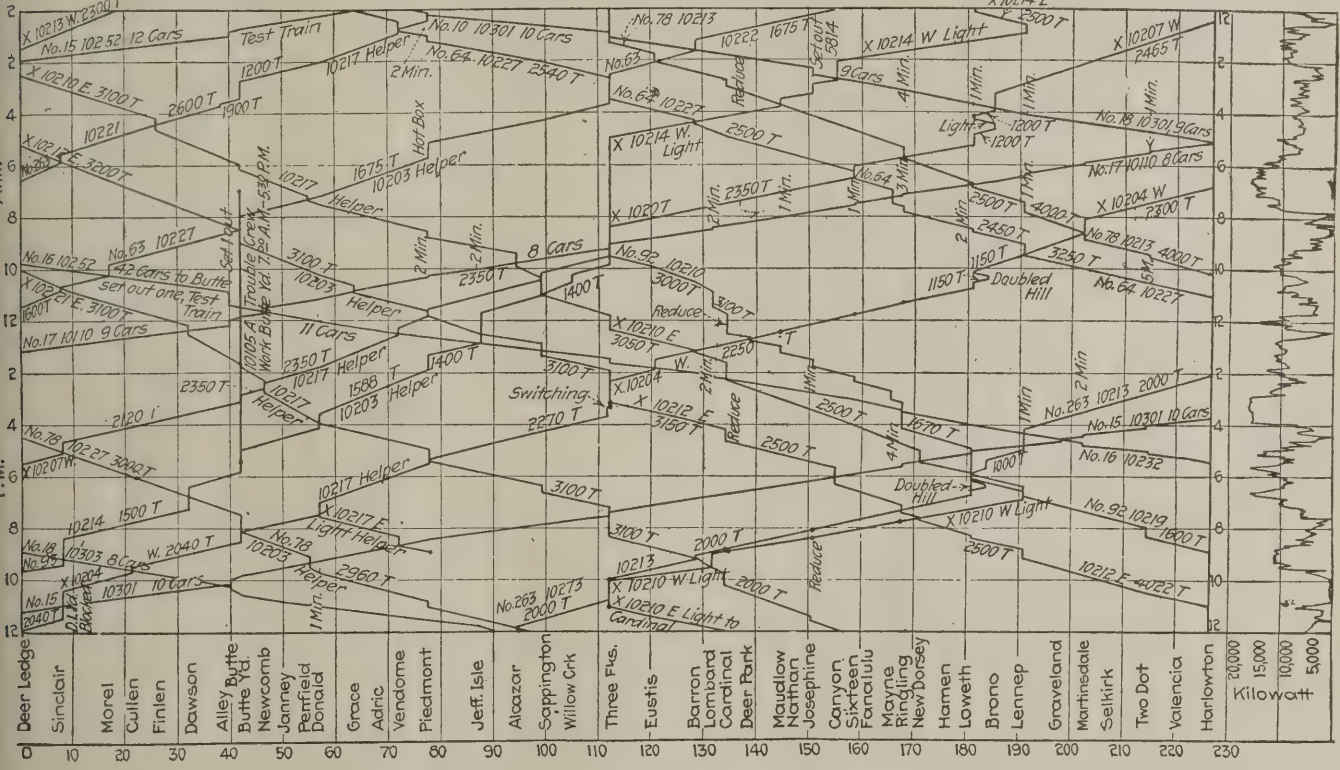
The effect of this limiting action is clearly indicated by the graphic timetable which shows train movements on the Rocky Mountain division for February 19, 1920, and corresponding load curve traced by tapalog meter of the power indicating and limiting system with the load limit set at 16,000 kw.

The percentage of time when the limiting action will take place will, for a given amount of business, depend on the demand setting and on the possibilities of spacing the trains so that as few as possible will at one time be operating on the heavier grades, the latter matter, except as regards passenger trains and certain time freights, being to a considerable extent in the hands of the train despatchers. The slowing up of the train speeds, of course, results in increased train and enginemen's expense and increased time in getting freight over the road, and a proper balance must be struck between this increased expense and the saving in power cost, determining upon the limit setting expense accordingly.

Table II

Month	Limit setting	Avg. monthly kw., actual	Per cent time limiting action takes place
July, 1918	12,000	8,020	13.0
August, 1918	12,000	7,820	15.5
September, 1918	12,000	6,675	8.2
May, 1919	14,000	7,840	4.62
August, 1919	14,000	7,650	4.12
September, 1919	14,000	8,230	9.50
October, 1919	14,000	8,420	10.65
November, 1919	14,000	7,115	8.24
February, 1920	16,000	8,625	2.40
March, 1920	16,000	8,680	2.20
April, 1920	16,000	8,620	1.90

The figures shown in Table II will give an idea of the percentage of time the limiting action takes place with average kw. load and settings as indicated, this percentage being based on the number of hours the limiting system was actually in service.



Graphic Train Sheet and Load Curve for Rocky Mountain Division

Table III—Power Input to System Chargeable to Locomotives

	Rocky Mountain Division			Missoula Division		
Month	Actual kwh. system input for locomotives	Net kwh. input at locomotives	Ratio	Actual kwh. system input for locomotives	Net kwh. input at locomotives	Ratio
January	6,381,233	4,838,480	75.9	5,540,581	3,753,430	67.6
February	4,610,607	2,921,840	63.3	4,107,960	2,702,710	65.8
March	5,795,859	4,351,126	75.2	5,412,048	3,469,120	64.2
April	5,949,840	3,962,650	66.6	5,429,932	3,574,080	65.8
May	5,803,455	4,146,517	71.4	5,745,397	3,795,770	66.2
June	5,662,650	4,100,810	72.3	5,697,785	3,853,590	67.6
July	5,744,738	3,794,940	66.2	5,318,692	3,505,630	65.8
August	5,648,815	3,755,280	66.5	5,133,008	3,255,820	63.4
September	5,892,430	3,799,830	64.5	5,102,562	3,434,010	67.2
October	6,222,486	3,971,149	63.8	5,389,883	3,654,955	67.8
November	5,095,937	3,425,458	67.2	4,879,130	3,181,456	65.2
December	5,809,976	3,830,870	65.8	4,971,601	3,382,700	67.9
	68,618,026	46,898,850	68.3	62,728,579	41,563,271	66.3

In arriving at the amounts chargeable for power against the different respective classes of train service, the total kilowatt hours to be paid for, that is, the actual kilowatt hours, or same increased, if necesary, to correspond to a minimum 60 per cent load factor, is taken and from it is deducted the kilowatt hours metered against substation lighting, auxiliary power, signal system, supply, etc., amounting to about one per cent. The remaining kilowatt hours are then split against the different classes of train service, freight, passenger and non-revenue, in proportion to the total net kilowatt hour readings obtained for these respective services from wattmeters installed in the locomotives. These readings are taken by the engine crew on entering and leaving the engine on a form provided for the purpose, and a record of the power consumption of each train is thus obtained. The readings are referred to as "net" readings, as they represent motored energy less regenerated energy.

Table IV—Comparative Power Input of Substations

Rocky Mountain Division	Average annual kw. input net to motor-generators		Missoula Division	Average annual kw. input net to motor-generators	
Substation	*Total	**Per motor-gen.	Substation	*Total	**Per motor-gen.
Two Dot	895	813	Gold Creek	1,150	1,128
Loweth	962	783	Ravenna	915	1,115
Josephine	1,014	1,013	Primrose	908	925
Eustis	1,022	1,016	Tarkio	843	803
Piedmont	1,218	617	Drexel	790	778
Janney	1,390	559	East Portal	1,390	778
Morel	1,047	1,072	Avery	812	523
System total	7,548		System total	6,808	

*Total kwh.—Hours in year; 8,856 hours being taken, as four days in December are included.

**Total kwh.—Total running hours of motor-generators.

The ratio of the total net locomotive wattmeter readings, all services, to the total actual kilowatt hour input to system chargeable to locomotives for the various months of 1919 and for the whole year is given in Table III.

As there are no wattmeters installed in the direct current side of the substations, a ratio for net substation output to system input or to locomotive input is not obtainable. There are, however, wattmeters in the circuits of the individual motor-generator sets, and the figures shown in Table IV considered in connection with the profile, will be of interest in showing the manner in which the energy is distributed among the respective substation, average kw. being used for convenience instead of total kilowatt hours, and the whole of the year 1919 being taken.

TABLE V—POWER CONSUMPTION FOR FREIGHT AND PASSENGER SERVICE

ROCKY MOUNTAIN DIVISION

Freight Service

Month	Thousands gross ton miles trailing	Net kwhr. per thousand trailing		Gross ton mile train		Load factor	Cost kwhr. per thousand trailing gross ton mile, cts.
		At high tension bus	At locomotive	At high tension bus	At locomotive		
January	98,478	47.8	36.3	41.2	31.3	63.7	25.7
February	79,859	43.1	27.3	37.3	23.6	57.7	24.0
March	118,297	39.0	29.3	33.9	25.5	65.5	20.9
April	121,646	38.5	25.6	33.1	22.0	61.1	20.7
May	124,395	36.5	26.1	31.7	22.6	56.0	20.9
June	122,264	36.7	26.2	31.7	22.9	56.4	20.9
July	120,723	36.7	24.3	31.6	20.9	55.4	21.3
August	111,092	40.9	27.2	34.9	23.2	54.6	22.4
September	115,787	39.7	25.6	34.1	22.0	58.8	21.7
October	108,920	45.8	29.2	39.4	25.1	60.0	23.6
November	86,267	44.0	29.6	37.7	25.3	50.9	27.8
January - November ....Averages		40.5	27.7	34.8	23.8	57.3	22.5

MISSOULA DIVISION

Month	Thousands gross ton miles trailing	Net kwhr. per thousand trailing		Gross ton mile train		Load factor	Cost kwhr. per thousand trailing gross ton mile, cts.
		At high tension bus	At locomotive	At high tension bus	At locomotive		
January	87,598	44.3	29.9	38.6	26.1	....	23.8
February	73,481	39.8	26.2	35.2	23.2	....	21.7
March	103,613	40.3	25.8	35.6	22.8	....	21.6
April	109,133	38.5	25.4	34.1	22.4	....	20.2
May	118,331	37.9	25.1	33.5	22.2	....	20.3
June	116,660	37.8	25.6	33.3	22.5	....	20.3
July	106,045	38.1	25.0	33.5	22.0	....	20.4
August	101,017	38.8	24.6	34.3	21.8	....	20.8
September	99,578	38.5	25.9	34.1	22.9	....	20.6
October	100,504	40.0	27.1	35.3	23.9	....	21.4
November	78,459	45.3	29.5	39.2	25.5	....	24.3
January - November ....Averages		39.7	26.3	35.0	23.1	....	21.3

ROCKY MOUNTAIN AND MISSOULA DIVISIONS COMBINED

Month	Thousands gross ton miles trailing	Net kwhr. per thousand trailing		Gross ton mile train		Load factor	Cost kwhr. per thousand trailing gross ton mile, cts.
		At high tension bus	At locomotive	At high tension bus	At locomotive		
January-November	2,302,507	40.1	27.1	34.9	23.5	....	21.9
January-December	2,476,085	....	....	....	....	....	22.3
		Passenger Service					
January - November	340,480	56.8	38.7	39.7	27.1	....	38.4
January - December	378,080	....	....	....	....	....	38.1

The figures in Table V show for the year 1919 the net kilowatt hours per thousand gross ton miles for freight revenue service and passenger service, respectively, and the corresponding cost of these kilowatt hours at the high tension bus or point of delivery of the power to the railway system. The lesser consumption of energy during the summer months, as compared with the winter months, will be noted. The figures for the passenger service are approximate, as the ton mile data are based on the assumption of an average weight per car, no record of the particular cars handled in all the separate trains being available:

TABLE VI—OPERATING COSTS FOR 1919

The cost of maintaining and operating the transmission lines, substations, and trolley system, for the year 1919 is given below and a final figure thus arrived at showing the approximate total operating costs involved in the delivery of the electric energy to the locomotives:

	Account	Total all services	Per unit
255.	Power substation buildings......	$8,487	$606.00 per building
257.	Power transmission system......	1,773	4.87 per mile
259.	Power distribution system......	78,461	179.00 per route mile
261.	Power line poles and fixtures...	24,299	55.50 per mile
306.	Power substation apparatus......	40,224	2,870.00 per station
383. 395.	Train and yard power produced.	102,152	7,300.00 per station
	Total	$255,396	

1. Cost per thousands gross ton miles trailing freight as actually distributed in accounts.. 28.8c
2. Cost per thousands gross ton miles train freight as actually distributed in accounts.. 24.9c
3. Cost per thousands gross ton miles trailing freight on basis distribution in proportion to freight kwhr........................... 30.2c
4. Cost per thousands gross ton miles train freight on basis distribution in proportion to freight kwh.............................. 26.2c
5. Cost per actual kwhr. delivered to locomotives.................. 1.1c

The above unit figures include the cost of power.

Conclusions

The installation being comparatively new it might naturally be assumed without consideration of other facts that the figures for the maintenance are considerably lower than those which will eventually obtain, but it should be borne in mind that the maintenance and operating costs given will, except for power, remain more or less constant as far as any consideration of their being affected by the business handled is concerned, so that the cost per thousand ton miles would be correspondingly reduced as business is increased. It is also expected that considerable improvement will be effected in maintenance methods, which would again tend to reduce costs. The figures are therefore given merely to show the results which are at present being obtained.

Welding Cast Iron

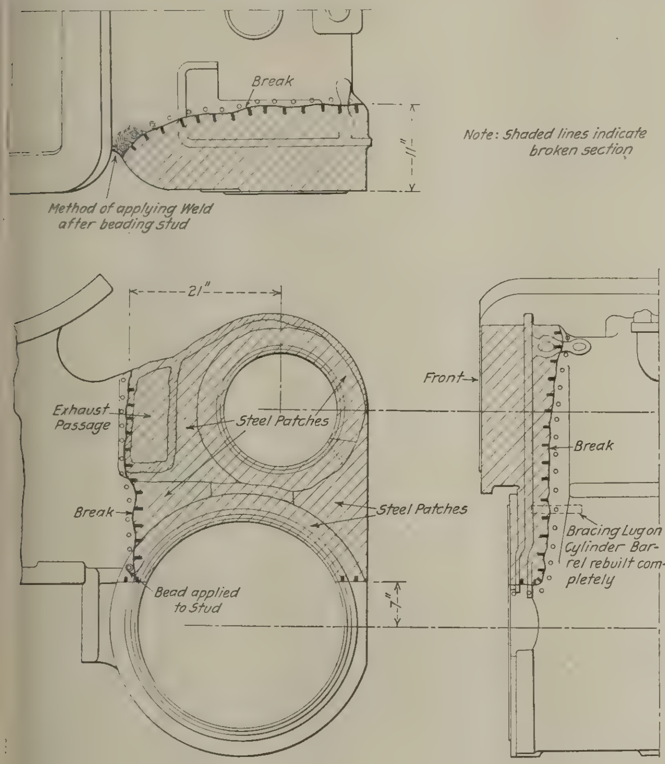
By JOHN C. WEIS

One of the most difficult problems in the welding art is the welding of cast iron. The low tensile strength of cast iron as compared with steel makes it a very difficult problem, even for the experienced welder, to obtain the necessary fusion so vitally required to complete a successful weld. The difficulties with which the work is performed calls for a redoubling of efforts and diligence on the part of the operator in order that he may secure the desired results in the placing of the metal.

A large number of the important parts of modern locomotives, stationary, turbine and gasoline engines of today are constructed of cast iron. Many of these castings are extremely high in price, due to the cost of labor and materials involved, as for example the cylinders and valve chambers on all locomotives. This portion of the locomotive is one of its most vital parts as well as one of the most expensive in the point of first cost. The same thing is true of engines of other types.

Previous to the inauguration of electric arc welding, a failure or break occurring on certain parts of locomotive cylinders or valve chambers, in a position impossible to pack with sal ammoniac and sulphur mixture, or to repair by the usual patch bolt method, necessitated the scrapping of the casting. Such a procedure involved an enormous loss of money through the resulting loss of time while the engine was laid up for repairs as well as for the cost of material and labor expended in removing the defective cylinders and applying new ones. The expense involved in such work derived from a statement covering actual cost of repairs to a cylinder by the old method, amounted to exactly $1,400 as compared to $200 for the same class of repairs to a cylinder using the electric arc. This shows an actual saving in material or upkeep cost of 700 per cent.

During my experience both as a welder and in a supervisory capacity, it has been my good fortune to have the welding of a great many patches, among which were some very difficult ones on cases of this type. I am proud to say I have as yet had no failure reported due to imperfection or flaw in a weld. This is not stated as a boast but is merely to emphasize the previous statement in regard to the necessity for diligence and concentration of effort. I do not wish to create the impression by this that I have not had engines reported back for broken cylinders after they have been welded, but I do wish to state most emphatically that in every case of this kind the second fracture occurred on a part other than that previously welded.


Break
Note: Shaded lines indicate broken section
Method of applying Weld after beading stud
21"
Exhaust Passage
Steel Patches
Front
Break
Break
Steel Patches
Bracing Lug on Cylinder Barrel rebuilt completely
Bead applied to Stud
7"

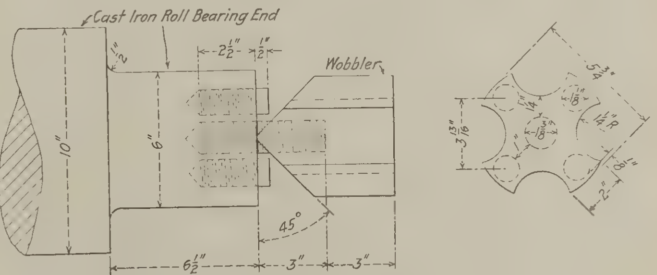
Steam Cylinder Repaired with Numerous Welded Patches

The larger of the two illustrations shows an actual fracture that occurred on one of the largest types of freight locomotives. The job was a trifle more difficult than the usual run of this kind of work, for in this particular case we had to build the bracing lug on cylinder barrel and bottom of valve chamber proper, extending about 8 in. The complete front end of this valve chamber and upper part of the cylinder had been previously steel patched and arc welded where a piston rod had broken at the crosshead, fracturing valve chamber and causing a break to occur about 2 in. from the point where previously welded, but without affecting the welded section in the least. The fracture or broken patch was rewelded and the engine is still in service and has been giving excellent results ever since this repair was made, about seven years ago. On this particular job a net saving of 700 per cent of the cost necessary to replace the broken cylinder with a new one was effected, for with the old methods of patch bolting or sal ammoniac mixture the repair would have been impossible, due to the difficulties encountered. In order to perform a successful fusion or weld, this class of welding calls for an operator of experience and ability and one who is thoroughly familiar with the handling and placing of his arc.

In the very beginning, of course, we were not so very successful in this kind of work, due to the lack of experience, but from the information derived from failures during this experimental period, we perfected the system of welding these parts and, as previously stated, I have as yet to receive a report of a failure on any part so repaired.

In this regard I cannot emphasize too strongly the main essential is the operator, next in importance is the preparation of the parts to be welded, which we do in the following manner: After the face of the part to be welded has been beveled to the proper 45 deg. angle, we drill and tap this face for the application of steel studs of required thickness. We cannot offer any specific rule other than that of condition. For example, assume thickness of cylinder wall to be 1¼ in., in which case we usually apply ¾-in. studs in order to avoid the tendency to weaken the original structure any more than is absolutely necessary. The studs are placed in a zigzag row by spacing them 2 in. from center to center. Each stud projects about ¼ in. from the face of the part to be welded. The parts must be clean and smooth, free from rust and chisel gashes in order to eliminate any tendency of the metal to adhere to the surfaces instead of fusing. We are now ready to apply the first layer of the weld.

Commence at either the bottom or top stud. A ⅛-in. electrode, carrying 18 volts across the arc and 140 amperes for best results, insures a proper fusing of metal, eliminating possible porousness or blow holes. Each stud should be completely welded before proceeding to apply metal in between and each weld should not be carried any further than the edge of the reinforced row, or outer row of studs, as all metal applied beyond this point is simply wasted. This is a very important point and must not be overlooked if successful results are to be obtained.



Studs Placed for Re-enforcement of Steel Wobbler

Assuming now that the studs have been padded or beaded, we are now ready to weld between them, as shown in the illustrations. In this case we use a 5/32-in. electrode carrying the same voltage, and 150 amperes in order to increase the welding tendencies or metal flow, thereby saving time. The process is continued, applying layer by layer until the space is completely filled.

I would particularly call attention to another recent triumph of this process on a 10-in. cast iron "roughing" or "strander" roll used in connection with the rolling of steel in one of the largest steel plants in the east. The difficulty encountered in this particular case was the shearing or breaking off of the "wobbler" on the end of the roll, due to the intense strain imposed at this point. The wobbler being the most important as well as the weakest part of this device, the breaking of it, therefore, incurred the complete loss of the roll. My attention was called to this particular problem by the superintendent of the rolling mill, who requested that I visit his plant with the idea of offering any suggestions which might overcome the trouble. After examining the broken roll we found that we were able to repair it by drilling, tapping and applying steel studs to the bearing end in order to assist adhesion of metal to the cast iron part. We had the steel wobbler end machined to the proper 45 deg. angle after it had been drilled and tapped. I may say that this particular roll was repaired about one year ago and has been in continuous service ever since, giving excellent results. A comparison of figures showing the amount saved by repairing the roll in this manner is given, as follows:

Cost of Repairs by Replacement

One steel roll (in the rough) at	$31.75
Time lost by 14 men at an average price of 55 cents per hour on the basis of 2½ hours each, due to the breaking of roll and attendant loss of time awaiting necessary repairs, due to removing defective roll and replacing with new	19.25
Machining new roll for use	25.50
Total cost	$76.50

Cost of Repairs by Welding

To laying out end of broken roll, including drilling and tapping for application of studs, removing and replacing of roll:	
Time lost by 14 men at an average price of 55 cents per hour on the basis of 2½ hours each, due to the breaking of roll and attendant loss of time awaiting necessary repairs, due to removing defective roll and replacing with new	$19.25
Five steel studs at 2 cents each	.10
Seven pounds of welding wire at 9 cents	.63
Welding, 1 operator at 82 cents per hour, four hours	3.28
Total	$23.26

In conclusion, I would again say that the reason for a great many failures on cast iron welding is the lack of confidence on the part of the operator, partly because he has heard that it cannot be successfully welded, but mainly due to the improper handling of his arc through letting it play upon the cast iron instead of using the short arc and crowding that to the limit, thus obtaining proper fusion.

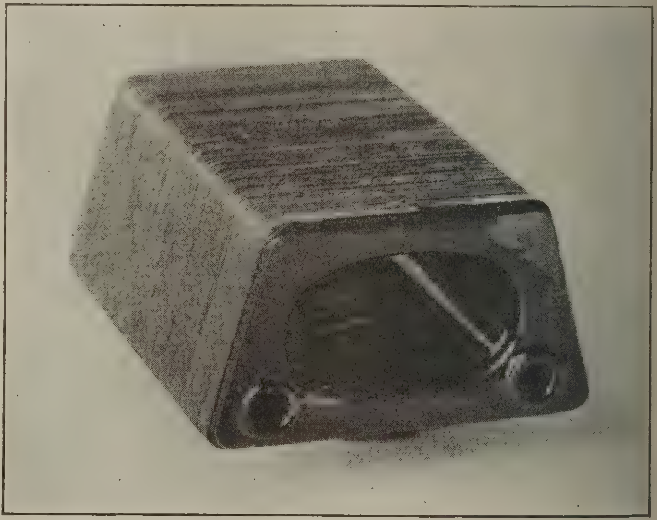
For this class of operators, for their improvement and the continuous success of this method, I beg to offer this very important fact: At the time that this government had taken over the interned German ships during the late war, the cast iron parts of their engines were wantonly destroyed, cracked and broken in every conceivable way. The damage was so bad, in fact, that the time estimated by the government engineers necessary to replace the destruction was about 18 months at an estimated cost of $18,000,000, while by using the same method of applying the weld as described in this article these same ships were successfully repaired and were transporting troops and munitions in just three months, due to the perseverance and diligence of effort on the part of the men "behind," and because they had the confidence to perform the impossible.

Laminated Iron Slot Wedges

Years ago the manufacturers of electrical machinery discovered that the large coil slots used in big alternating current generators were the cause of unnecessarily large iron losses and of large reciprocating mechanical forces caused by the shifting of the magnetic flux.

It was found that this objection could be corrected by making the top of the slot narrower than the bottom. A number of machines have been made with this kind of slot; but the method involves difficulties of construction, as the coils then have to be designed so that they can be pushed in through the slot from one end.

Another method of obtaining the desired flux distribution is to equip a machine which has the ordinary open slot with a type of magnetic wedge in place of the usual wood, fibre, or brass wedge. One of these magnetic wedges, which has passed through various stages of development, is shown in the illustration. It is made up of a large number of pieces of thin, soft iron insulated from each other by an insulating varnish. The pile of laminations is completed at each end by a flanged stamping, and the whole is maintained as a unit by two tubular rivets. The wedge is 2⅞ in. long and 2 3/16 in. wide.



A Laminated Iron Slot Wedge for An Alternating Current Generator

The effect of using this kind of a wedge is to make the flux distribution more uniform, thereby equalizing the mechanical strain back and forth between the teeth and increasing the over-all efficiency of the machine.

Other Direct Current Magnetic Controllers

Dynamic Breaking Feature Expedites the Handling of Material by Means of Traveling Cranes

By Gordon Fox

IN the last issue of the *Railway Electrical Engineer* a number of types of direct current magnetic controllers were illustrated, and wiring diagrams given showing how the operation of each controller was effected. The present article is a continuance of the one in the July number, and discusses additional controllers possessing certain advantageous features. One of the most important of these is the dynamic breaking feature.

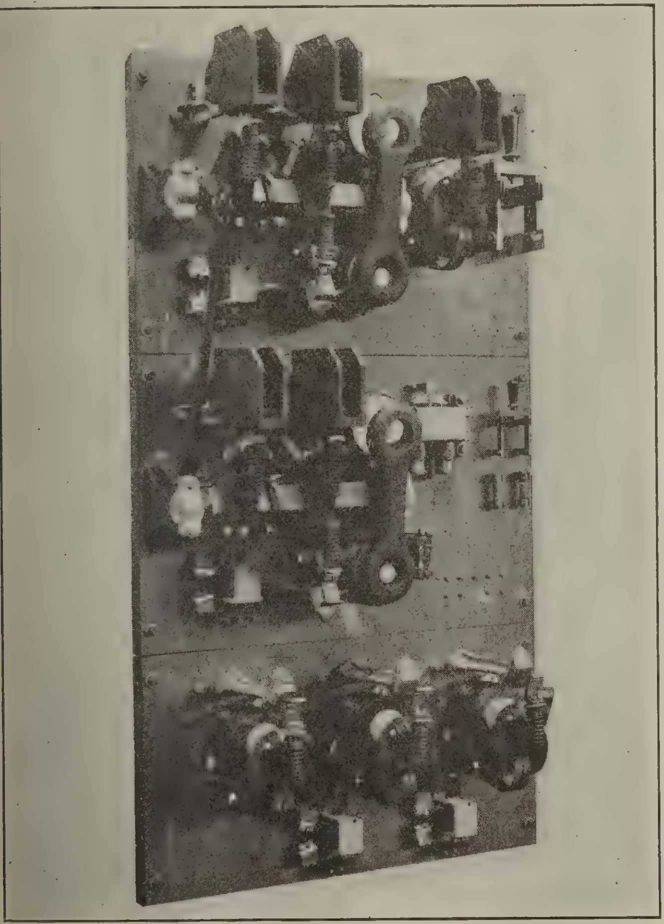


Fig. 1.—Reversing Controller With Dynamic Braking Feature

Reversing Controller with Dynamic Braking Feature

A reversing controller with two points of speed control and with dynamic braking on the off position, is illustrated in Fig. 1 and shown diagramatically in Fig. 2. This controller comprises a line switch and fused control switch for isolating the circuits. The directional contactors are handled by a two pole unit having a back contact, there being two such units, one for each direction. A line contactor *5* and three shunt accelerating contactors are supplied. A two coil overload relay and a voltage relay supply overload and no voltage protection. The operation is briefly as follows:

Off Position.—The master establishes a circuit from positive line through the coil of the voltage relay to negative, causing the voltage relay to close. A circuit is then established from positive line through the voltage coil and contact and overload relay to negative line. As this circuit does not include the master the voltage relay remains closed when the master leaves the off position. The voltage relay opens upon failure of voltage or when the overload relay opens. It is then necessary to return master to off position to reset the voltage relay.

First Point Forward.—The master completes a connection from positive line through the closing coil for the upper directional unit breaking the back, contact *1A* and closing directional contactors *1* and *3*. This control circuit passes thence through the closing coil for line contactor *5*, closing that contactor. The motor circuit is now completed through contractors *1*, *3* and *5* and the motor starts with full accelerating resistance in circuit.

Second Point Forward.—The master now completes a circuit, in addition to the one established on the first point, from positive line through the master and through the contacts of the series accelerating relay on the *1* and *3* contactor through the closing coil of shunt accelerating contactor *11*. When the series relay drops, completing this control circuit, contactor *11* closes shunting out the portion *R1* — *R2* of the accelerating resistance.

After contactor *11* has closed and the current has fallen off sufficiently to permit the series relay connected with this contactor to drop, a further control circuit is completed through the shunt closing coil of contactor *12*. Closure of this contactor, short circuits portion *R2* — *R3* of the accelerating resistance. In like manner accelerating contactor *13* closes after contactor *12* has dropped its series relay. Closure of contactor *13* connects the motor across the line.

Reverse.—Starting from rest in the reverse direction is the same as above described for the forward direction except that the directional unit *2* — *4* is used instead of unit *1* — *3*. This reverses the direction of current flow through the armature.

The two directional contactor units are so interlocked mechanically that both directional elements cannot be closed at the same time, although both back contact elements are free to do so.

Dynamic Braking.—This feature is accomplished by bringing the master to off position while the motor is under speed. This operation opens the directional contactors *1* and *3* and closes the back contactor *1A*, leaving full shunt field on the motor. The armature is short circuited through the resistance *B1* — *B2*. The rotation of the armature in the presence of the shunt field causes a voltage resulting in current flow through the braking resistance. The armature, acting as a loaded generator, quickly comes to rest.

The armature circuit during dynamic braking period is from the armature through the back contactor *1A*, through the series coil on the back contactor; which seals the contactor positively, through the braking resistance *B1* — *B2*, through the back contactor series coil and contactor *4A*, back to the armature.

It is to be noted that, a dynamic braking controller of this type is suited for use with compound wound motors only, since the shunt field is depended upon to provide the dynamic braking action. The heavier the shunt winding the greater the dynamic braking torque for a given armature current. The braking torque and current may be varied by adjusting the value of the braking resistance *B1* — *B2*.

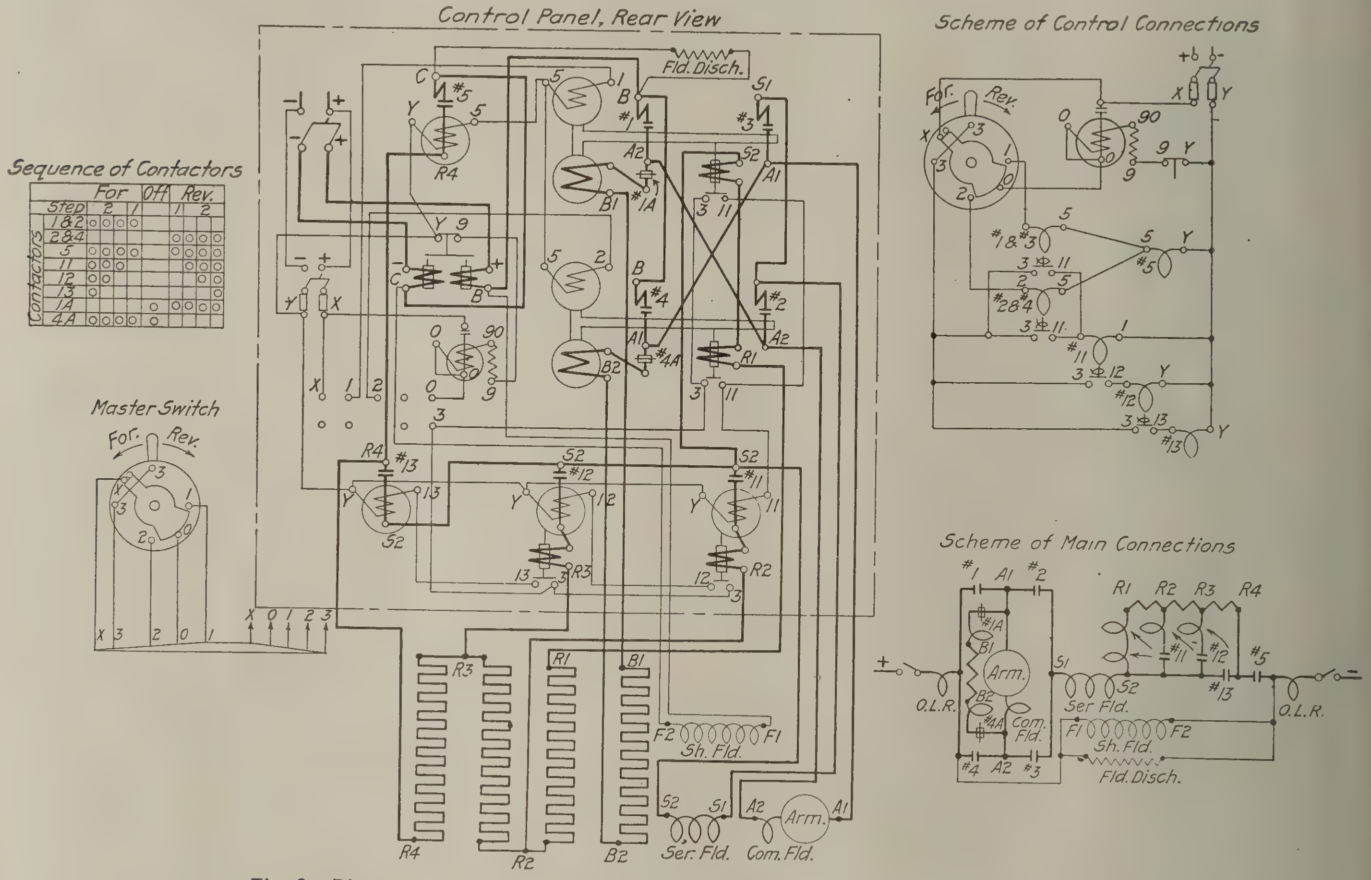
While it is possible to reverse the master quickly while the motor is running, high plugging peaks are prevented since the braking current through the series sealing coil holds the directional contactors open, counteracting the effect of the shunt closing coil, until the motor is slowed down sufficiently to permit reversal on straight accelerating resistance without severe peaks.

Overload Protection.—Excess current through either overload relay coil will open that relay, opening the holding circuit of the voltage relay and causing the latter to open. The main contactors then open.

No Voltage Protection.—Upon failure of voltage the voltage relay opens. This relay can be reset only by moving the master to the off position.

Reversing Controller with Shunted Armature

A simple reversing controller for a small motor, provided with an armature shunt for a slow speed point, is shown in diagram in Fig. 3. A controller by the same builder but of somewhat different make up is illustrated in Fig. 4.



Contactors	For				Off	Rev.			
Step	2			1		1	2		
1&2	○	○	○	○					
2&4						○	○	○	○
5	○	○	○	○		○	○	○	○
11	○	○	○				○	○	○
12	○	○						○	○
13	○								○
1A					○	○	○	○	○
4A	○	○	○	○	○				

Fig. 2.—Diagram of Connections, Reversing Controller With Dynamic Braking Feature

This controller comprises four directional contactors, *1*, *2*, *3* and *4*, mechanically interlocked; a line contactor; *5*; a shunt accelerating contactor *12*, an armature shunting contactor *11*, two overload relays of the time element trip, magnetic reset type and a small drum type master switch. The action may be outlined as follows.

Off Position.—All contactors open. A circuit is made at the master in the off position, energizing the reset magnets of the overload relays so that, if they have been tripped, they will be reset when the master is moved to the off position.

First Point Forward.—Control circuits are completed at the master, energizing the closing coils of directional contactors *1* and *3* and line contactor *5*, also armature shunting contactor *11*. When these contactors close the motor starts, at slow speed, with shunted armature and accelerating resistance in circuit.

Second Point Forward.—Conditions remain the same except that the control circuit for contactor *11* is opened at the master, causing that contactor to open. This removes the shunt around the armature and permits the motor speed to increase.

Third Point Forward.—The control circuit for accelerating contactor *12* is completed at the master. If the current relay attached to line contactor *5* has dropped, the closing coil of contactor *6* will be energized. Closure of this contactor short circuits the accelerating resistance and connects the motor across the line, bringing it to full speed.

Slow Down.—It should be noted that if the master be thrown from the 3rd point to 1st point, the armature is shunted and the series field strengthened while the armature may be running at fairly high speed. The resulting increase in generated armature voltage will cause rather heavy current flow through the armature shunt, retarding the armature. The action depends materially upon the nature of the load and the resistance values.

Reverse.—The action in the reverse direction is identical with that in the forward direction except that directional contactors *2* and *4* operate, reversing the armature current flow.

Overload Protection.—Two overload relays adjacent to positive and negative lines protect from excess current due to overloads, shorts and grounds. One relay, of the instantaneous trip type, is set at about 250 per cent full load, to protect only against shorts and grounds. The other relay, of the inverse time element type, is set at about 125 per cent full load to protect primarily against continued overload and secondarily against a ground current from that side of the line. These relays, once tripped, are held open by a catch. It is then necessary to energize the reset coil, to release them.

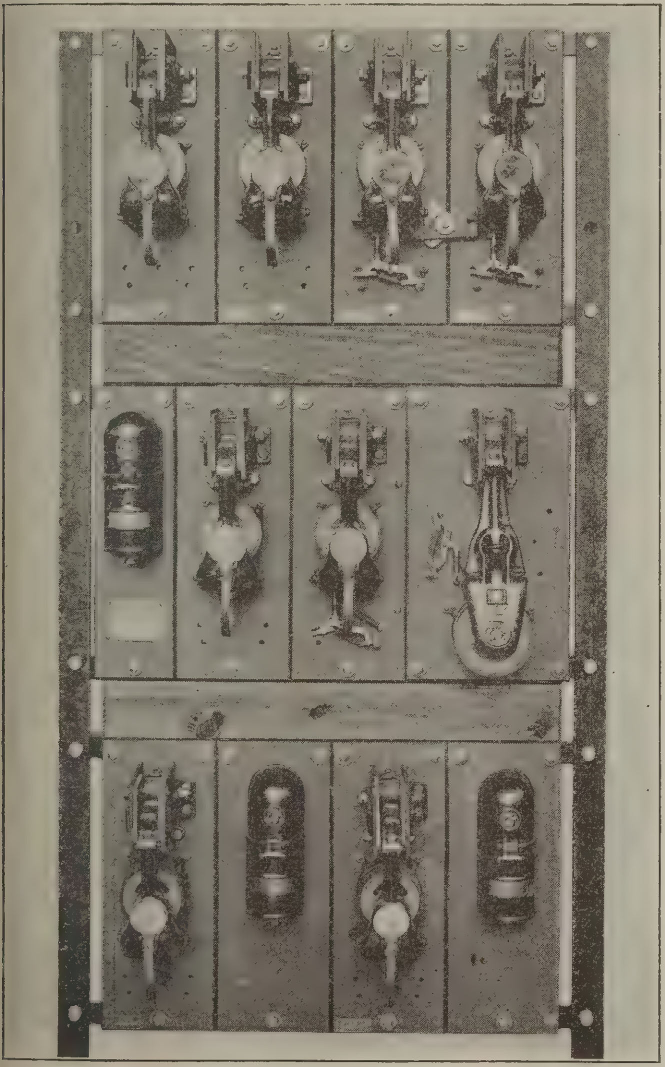


Fig. 3.—Magnetic Controller

No Voltage Protection.—This feature is omitted as unnecessary (for the particular application involved due to continuous attendance).

Comments.—It may be noted that resistance units are used in series with the closing coils of the contactors. This is said to render the contactors more rapid in action.

The curves in Fig. 5 set forth the motor characteristics which are obtained on the different controller points with a 12 hp. series motor. It will be noted that, on the first point, Curve *A*, with shunted armature, the speeds at all loads are restricted but more noticeably for the lighter loads. The characteristic is much like that of a compound wound motor. Curve *B* shows the action with the armature shunt removed but with accelerating resistance in circuit. Curve *C* is the motor characteristic. It may be noted that, if the motor is operating at a good speed, say 800 rpm as indicated on Curve *C*, and if the control is quickly thrown to first point, the armature current will momentarily reverse, as indicated by the point on Curve *A*. The effect of the reverse current is to quickly slow down the armature, along Curve *A*.

The torque curves are shown. With shunted armature the torque values for a given armature current are somewhat higher than normal due to the stronger field.

Crane Hoist Control Using Shunted Armature

The connections of a simple controller employed for crane hoist service are shown in Fig. 6. This controller is very similar to a straight reversing controller previously described except that an armature shunt is used for one direction of rotation. The panel carries four reversing contactors *1*, *2*, *3* and *4*. There is a line contactor *5* but this is not employed as a circuit breaker contactor as the panel has no protective features. A time element type accelerating relay is used, governing two shunt accelerating contactors *11* and *12*. A spring closed contactor *6* serves to close a dynamic braking circuit on the off position of the master. A knife switch serves to open the motor circuit while testing out the contactors. The ordinary accelerating resistors *R1* to *R3* are used. In addition, there is a bank *A1—S* which shunts the armature when switches *1* and *3* are closed in lowering. The action of the controller may be outlined as follows:

Off Position.—All contactors are open except *6*, which is spring closed. The series brake, being de-energized, is closed.

First Point Hoisting.—The master switch energizes the closing coils of directional contactors *2* and *4* and line contactor *5*. The opening coil of *6* contactor is energized, causing it to open. The motor circuit is completed through the armature, series field, series brake and accelerating resistance. The brake releases and motor starts.

Resistance *A1* — *S* is short circuited by contactor *2* and has no effect.

Second Point Hoisting.—When contactor *4* closes on first point an auxiliary contactor on this unit is also closed, completing the circuit of the accelerating relay closing coil. This coil is opposed by a series coil which delays its action. Its action is delayed by a dash pot also, giving time element acceleration. The contacts, *11A* and *12A*, of this relay close in succession after time intervals. When contact *11A* is made the closing circuit of accelerating contactor *11* is completed. That contactor then closes reducing the accelerating resistance.

Third Point Hoisting.—The circuit of the closing coil of *12* accelerating contactor is closed at the master. If the accelerating relay has closed the relay contact *12A*, the accelerating contactor *12* closes, connecting the motor across the line.

First Point Lowering.—The master energizes the closing coils of directional contactors *1* and *3* and line contactor *5*. The opening coil of contactor *6* is energized, causing it to open. The motor circuit is completed through the armature, series field, series brake and accelerating resistance. The brake releases and the motor starts to drive the hook downwards. It is to be noted that, resistance *A1—S* is now shunted around the armature. This passes current which strengthens the series field, thus limiting the speed at which a light hook may be driven downwards. In case of an overhauling load the armature generates a voltage causing a braking current to flow through the armature shunt, restricting the speed.

Second and Third Points Lowering.—The action of the contactors is the same as in hoisting. The effect of reducing the accelerating resistance is to increase the speed, due to increased armature voltage.

Deceleration from Lowering.—As the master is moved to the off position there is no material increase in braking effect until the off position is reached. Contactor *6* then closes. This short circuits the armature and series field through resistance *A1 — S* in such a manner that a braking current flows. As the series brake is not included in the circuit it sets and assists in stopping the motor.

Limitations.—This controller is a comparatively simple type for crane host service. It has not the uniformity of speed with varying hook loads nor the flexibility of adjustment or nicety of speed control in lowering obtainable with more complex types of crane controllers. The single resistance *A1—S* serves to limit the driving speed with light hook, to limit the overhauling speed with loaded hook and to limit the braking current in stopping. Its value must therefore compromise the various requirements.

Protection.—No protection is afforded at this controller. A separate "crane protective panel" not shown, is depended upon for overload and no voltage protection.

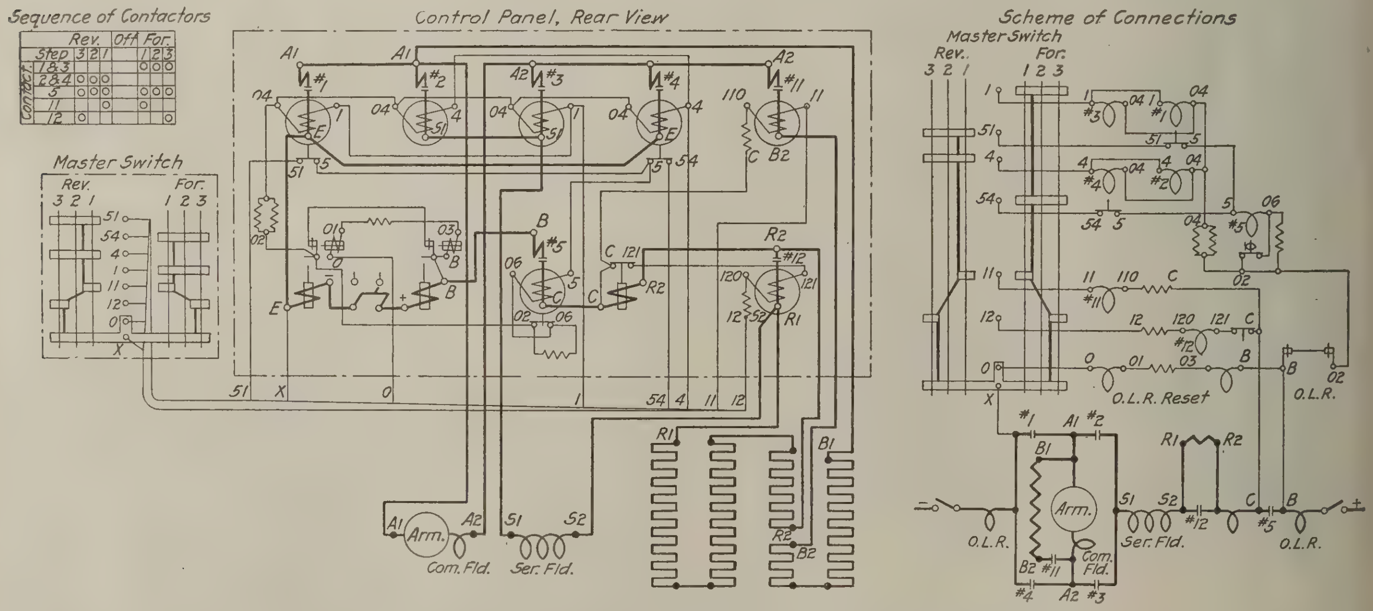


Diagram of Connections Reversing Controller With Shunted Armature Point

Crane Hoist Control with Dynamic Braking

A typical crane hoist controller suited to give good speed control with both light and loaded hook, is shown in Fig. 7. The connections are shown in Fig. 8.

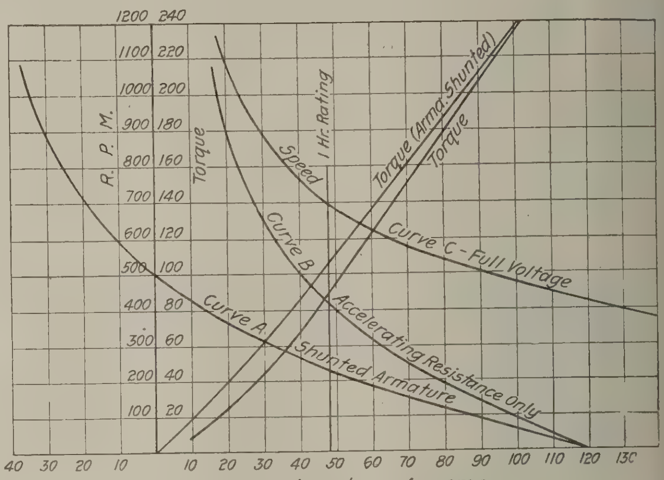


Fig. 5.—Characteristics of Series Motor With Resistance in Series and Shunt With Armature

The units which comprise this controller are as follows. A knife switch is supplied to disconnect motor and control circuits from the line. A fused control switch protects the control circuits and enables them to be isolated. Shunt contactor *1* is a directional contactor for hoisting. Shunt contactor *2* is a directional contactor for lowering. Shunt contactor *3* is a directional contactor used on lowering to connect the armature and series field in parallel across the line. Contactor *4* is a spring closed contactor which short circuits the armature through the series field on the off position, causing dynamic braking. Shunt contactor *5* is a line contactor to disconnect the motor from the negative line. Shunt contactor *6* serves to cut out resistance in series with the armature on the last point lowering, placing the armature across full voltage for high speed operation. Shunt contactor *7* serves several functions. In hoisting it acts as an accelerating contactor, closing on the last controller point. In lowering it closes on the first controller point permitting sufficient current to pass through the armature to give positive downward drive with a light hook. It is open on the 2d, 3d and 4th points lowering, introducing resistance *R5 — R6* into the armature circuit to restrict the lowering speed with loaded hook. On the last point lowering it closes, giving a high speed lowering point. Shunt contactors *11, 12* and *13* control the accelerating resistance in hoisting and the series field strength in lowering. There is but one overload relay this being of the instantaneous trip magnetically retained type. There are four separate resistor banks. Resistor *R1 — R4* is straight accelerating resistance in hoisting. In lowering, it serves to control the series field strength, hence the speed. Resistor *R11 — R12* is a current limiting resistor to avoid short circuiting the series field across the line, on the first lowering points. Resistors *R5 — R6* and *R6 — R7* function together to limit the armature current during both acceleration and deceleration in lowering. Resistor *R6 — R7* serves further to limit the dynamic braking in stopping while lowering. The action of the controller may be outlined as follows.

Off Position.—Contactor *4* is closed, since it is a spring closed contactor and its releasing coil is not energized. The armature is short circuited through the series field and resistance *R6 — R7*. This causes dynamic braking from a lowering direction only, since, from the hoisting direction, the braking current flow tends to demagnetize the series field.

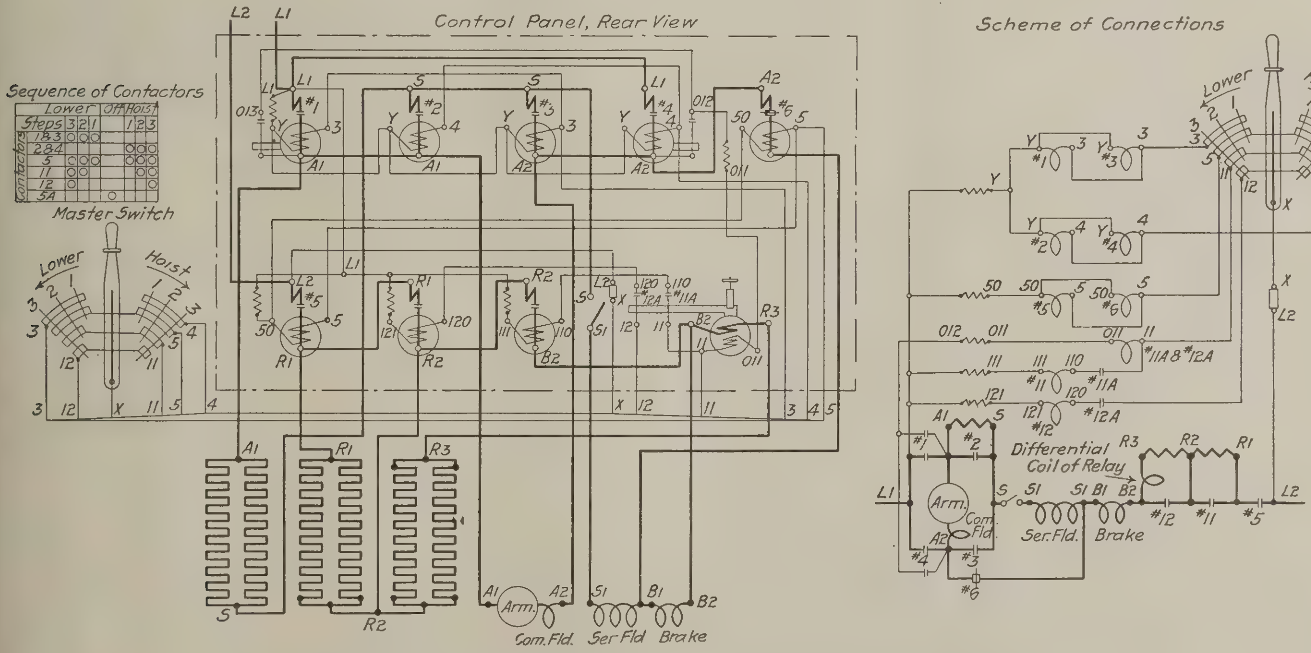


Fig. 6—Diagram of Connections. Crane Hoist Control With Shunted Armature

Contactor *3* remains closed if the master is brought to off position from a lowering position. The resistance in series with the closing coil of *3* contactor and master segment *5* causes only suffıcent current to flow through the closing coil to hold it closed provided it has been closed in lowering by being fully energized through master segment *8*. The purpose in retaining contactor *3* closed in stopping from lowering operation is because it is then a braking circuit and serves as a safeguard.

With the master in the off position the series brake is set.

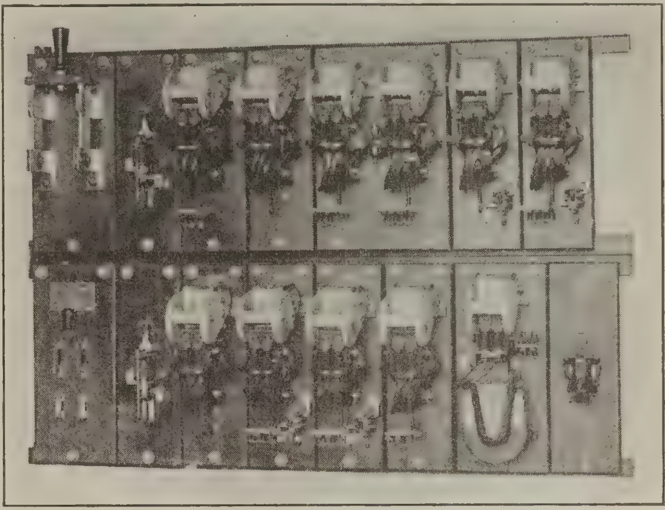


Fig. 7—Crane Hoist Controller. Dynamic Braking

First Point Hoisting.—Braking contactor *4* opens, its opening circuit being completed at segment *4* of the master switch. This removes the shorted path around the armature. Line contactor *5* closes simultaneously with the opening of contactor *4*, both being controlled from the same segment on the master. When contactor *4* opens, its auxiliary contact closes, completing the closing circuit of directional contactor *1*. Closure of contactors *5* and *1* completes the motor circuit in the hoisting direction.

Second Point Hoisting.—Accelerating contactor *11* closes, its closing circuit being made at master segment *5* and passing through an interlock on *1* contactor. Closure of contactor *11* reduces the accelerating resistance. Due to the interlock in the closing circuit of *11* contactor this contactor cannot close unless the directional contactor is closed first.

Third and Fourth and Points Hoisting.—Accelerating contactors *12* and *13* close in sequence under the control of the master and restricted also by series relays *11* and *12*. As further precaution interlocks on contactors *11* and *12* are used to insure the proper sequence of closure of these accelerating contactors.

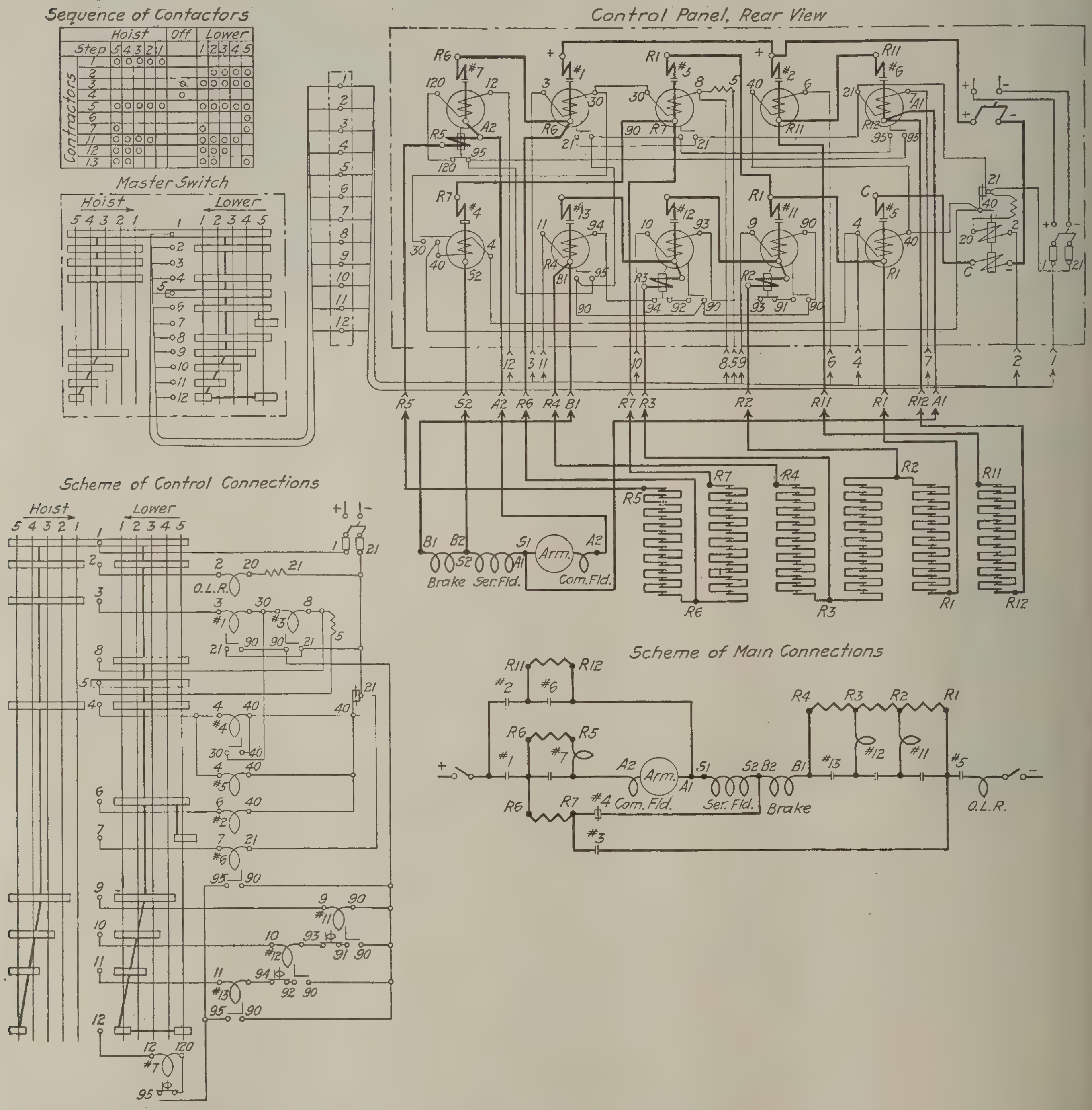


Fig. 8.—Diagram of Connections. Crane Hoist Controller With Dynamic Braking

Fifth Point Hoisting.—The closing circuit of contactor *7* is completed at master segment *12*. So soon as series relay *7* drops contactor *7* closes. This eliminates the last step of accelerating resistance and connects the motor across the line for full speed hoisting.

First Point Lowering.—When the master is thrown to first point lowering the first response is the opening of braking contactor *4* and closing of line contactor *5*, just as in hoisting. Simultaneously, directional contactor *2* closes. The series field and brake are now energized through the accelerating resistance. When contactor *4* opens, its auxiliary contact closes, completing the closing circuit of contactor *3* from master segment *8*. Closure of this contactor puts the armature in circuit through contactor *2*, resistance *R11* — *R12*, through resistance *R5* — *R6* — *R7* and through contactors *3* and *5*.

When contactor *3* closes it becomes possible for resistor contactors *11*, *12*, *13* and *7* to close, their circuits being closed at the master and passing through the auxiliary contact of *3* contactor. Closure of contactors *11*, *12* and *13* gives a strong series field which assists in starting the drive to lower and then restricts the lowering speed. Closure of contactor *7* cuts out resistance in the armature circuit, giving the armature a good starting torque for starting a light hook downwards.

Second Point Lowering.—Conditions remain as on the first point except that contactor *7* opens, introducing resistance in the armature circuit. If a light hook is being driven down the lowering speed will decrease slightly. If the load is overhauling, the introduction of resistance in the braking circuit causes an increase in speed since the armature may generate a voltage higher than impressed voltage by an amount corresponding to the drop in the armature circuit. For light hook lowering the second point is slower than first point but, with a loaded hook, the speed on second point is faster than on first point.

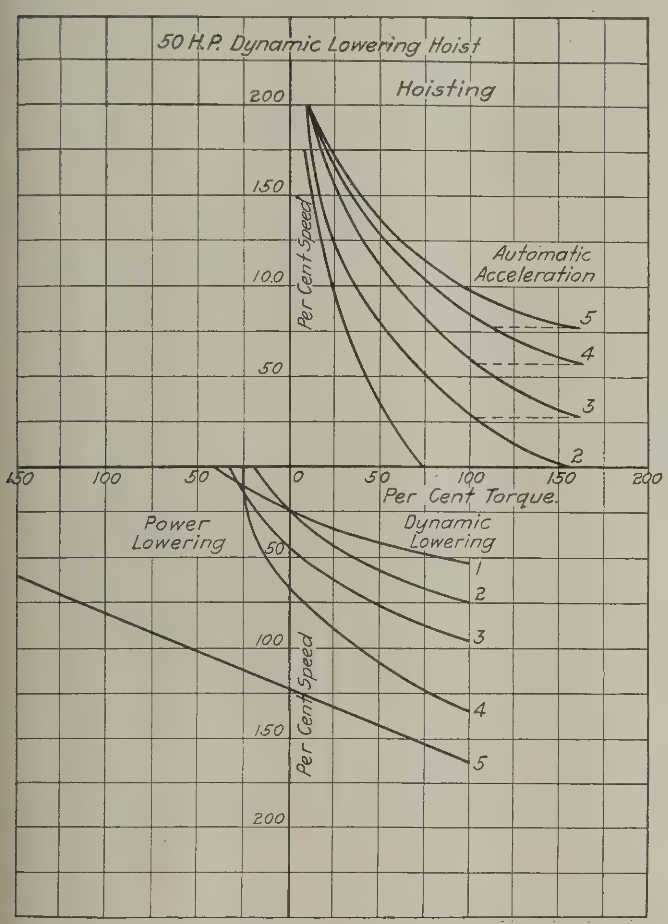


Fig. 9.—Characteristics of Crane Hoist Control With Dynamic Braking

Third Point Lowering.—Contactor *13* opens. This weakens the series field and thus causes an increase in speed for all loads.

Fourth Point Lowering.—Contactor *12* opens. This weakens the series field further and causes a further increase in speed.

Fifth Point Lowering.—Contactor *13* opens, weakening the series field further, tending to increase the speed. Contactor *6* closes. This tends to strengthen the series field and thus to offset the effect of opening contactor *13*. The voltage impressed on the armature circuit is increased, however, tending to increase the speed. This influence is neutralized in part by closure of contactor *7* which decreases the resistance in the braking circuit tending to decrease the speed in lowering a load and to increase the speed in driving down a light hook. The result is a fast speed point for both loaded and light hook.

Deceleration from Lowering.—In bringing to a stop a load being lowered, the motor is called upon to exert braking action. As the master switch is thrown from an advanced lowering point toward the off position, the resistor contactors *13*, *12* and *11* close in sequence. One result of this action is the strengthening of the series field. As the armature is revolving rapidly its generated voltage increases. This voltage forces a braking current through the circuit *A1*, series field, series brake, resistors *R4* — *R1* as in circuit, contactor *3*, resistors *R7* — *R6* — *R5* to *A2*. This current further strengthens the series field, so that the action is cumulative. As the series brake is included in this dynamic braking circuit it is held open and is not called upon to decelerate the load. When the master reaches the first point, contactor *7* closes, reducing the resistance in the braking circuit by shorting *R6* — *R5*. When the master reaches the "off" position contactor *4* closes. The dynamic braking circuit is now from *A1* through the series field contactor *4* and resistance *R7* — *R6* — *R5* to *A2*. These resistors permit a rather heavy flow of braking current, quickly stopping the armature. As the series brake is not included in the circuit, it is released, helping to bring the load to its final stop and holding it thereafter.

Speed Control.—It is to be noted that several banks of resistance are employed to control the conditions while lowering. By variation of these resistors the performance of the drive may be modified.

Resistor *R11* — *R12* is in circuit during the lowering operation only. Its prime function is to limit the voltage impressed upon the series field while *R4* — *R1* is shorted and to resist the impressed armature voltage in starting to lower. Increasing resistance *R11* — *R1* decreases the driving torque in starting and decreases the speeds in lowering particularly with light loads, except on the last point, when this resistance is out of circuit.

Resistor *R1* — *R4* is used in both hoisting and lowering operations. This resistance is proportioned for the hoisting service. In cases where a high lowering speed is desired the step *R1* — *R* may be increased to give a weak field point in lowering. This change reduces the torque and current on first point hoisting.

Resistor *R6* — *R7* is in circuit only while lowering. It functions to control the lowering speed and to limit the current in braking while lowering. Increasing *R6* — *R7* decreases the power torque in starting. It decreases slightly the lowering speed with a light hook and increases materially the lowering speed with loaded hook. It decreases the braking current in stopping. In driving down a light hook the drop in *R6* — *R7* is subtracted from armature impressed volts, decreasing armature speed. In lowering a load with braking action the armature must generate additional voltage by the amount of the drop in *R6* — *R7* before it can exceed the voltage impressed from *A1* to *R1* and set up the flow of braking current. This means that the armature will speed up in order to generate the voltage required to give a balanced condition.

Resistance *R5* — *R6* acts as accelerating resistance in hoisting. In lowering it functions similarly to *R6* — *R7* except that it is cut out on the first point to give a good starting torque. It is cut out also on the last point lowering in order to restrict the speed in lowering a load and increase the speed in driving down a light hook, thus equalizing speeds for the different conditions. A change in *R5* — *R6* has an influence similar to a change in *R6* — *R7* except on the first and last points lowering, when *R5* — *R6* is shorted. By selection of the point of adjustment the action can be restricted to intermediate points or can be made effective for all lowering points, as desired.

Overload Protection.—Overload protection is afforded by one relay on the panel. Operation of this relay opens the circuits of contactors *5*, *4* and *2*. Contactor *4* in turn affects contactor *1*. The motor is thus isolated in any case. When the relay is tripped by the action of the series coil it is held open by the shunt coil until the master is moved to the off position. Protection is provided on this panel by the overload relay in one side of the line. Protection in the other side of the line is afforded in advance of this control at a so-called crane protective panel, not shown.

No Voltage Protection.—This protection is not provided, being cared for by the protective panel mentioned.

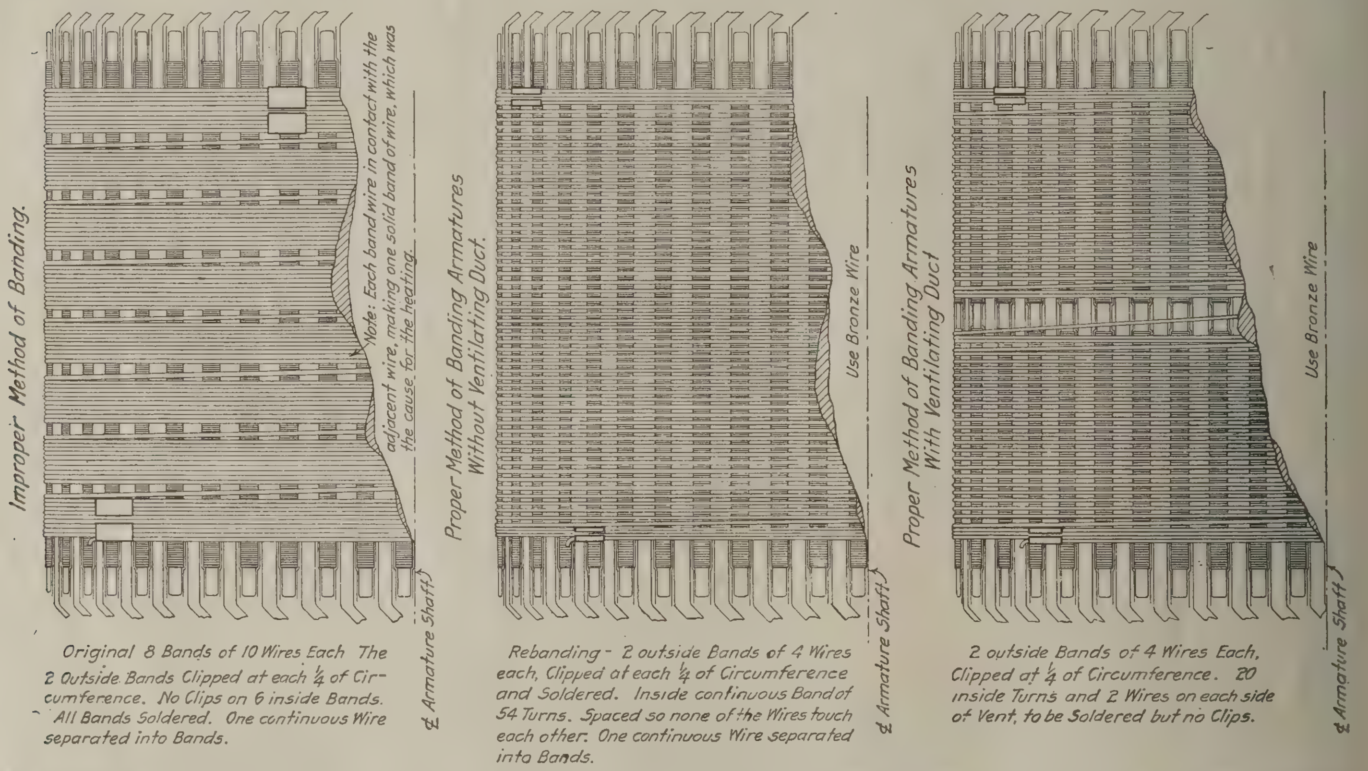
Fig. 9 shows the characteristics of operation of a crane hoist controller similar to that discussed above. Distances above the origin represent hoisting speeds; distances below the origin represent lowering speeds. Distances to the right of the origin represent torques in hoisting direction; those to left of origin represent torques in lowering direction. It is to be noted that the lowering curves show values for driving downward light loads as well as for restraining heavy loads. The several curves show the operation upon the various resistance steps.

There was a man in our shop, he was so wondrous wise; he wouldn't wear his goggles—now he has no eyes.—*Fred Meyers.*

Improperly Placed Band Wires

Proper and improper methods for putting band wires on 250-volt armatures are shown in the illustration. The importance of doing this work correctly is very clearly brought out by the experience of J. J. Hack, engineer of train lighting, heating and ventilation on the Southern Pacific Lines at West Oakland, Calif. Some time ago Mr. Hack had occasion to purchase a new 250-volt armature to be used in a two-pole, 35-kw., 220-volt generator equipped with interpoles operating at 3,600 r. p. m. The generator was used in one of the shops for the purpose of supplying lighting current to the shops, roundhouse and station.

It was noticed when the new armature was put into service that it became very hot, the temperature rising way beyond the safe temperature limit without any load on the machine whatever. It was finally discovered that the excessive temperature was due to the improper placing of the band wires, which were located as shown in the sketch at the left. When the difficulty was remedied by arranging the bands properly the armature and generator worked perfectly. The sketch at the right and the one in the center show the proper method of placing band wires on armatures with and without ventilating ducts. To any who have not had the experience related, the foregoing information may prove of value in solving what otherwise might be a puzzling problem.


Improper Method of Banding.
Note: Each band wire in contact with the adjacent wire, making one solid band of wire, which was the cause for the heating.
℄ Armature Shaft
Proper Method of Banding Armatures Without Ventilating Duct.
Use Bronze Wire
℄ Armature Shaft
Proper Method of Banding Armatures With Ventilating Duct
Use Bronze Wire
℄ Armature Shaft

Original 8 Bands of 10 Wires Each The 2 Outside Bands Clipped at each ¼ of Circumference. No Clips on 6 inside Bands. All Bands Soldered. One continuous Wire separated into Bands.

Rebanding - 2 outside Bands of 4 Wires each, Clipped at each ¼ of Circumference and Soldered. Inside continuous Band of 54 Turns. Spaced so none of the Wires touch each other. One continuous Wire separated into Bands.

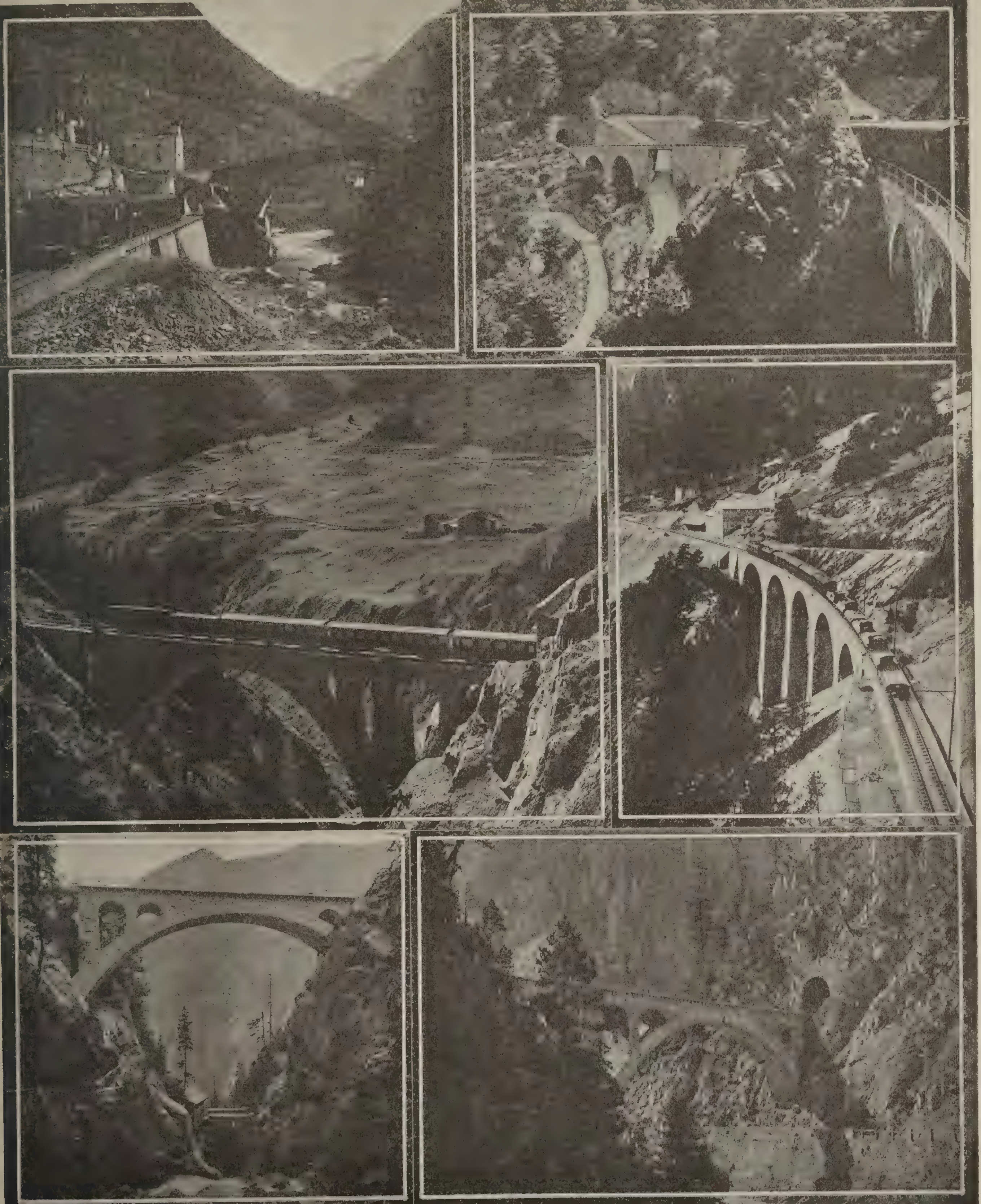
2 outside Bands of 4 Wires Each, Clipped at ¼ of Circumference. 20 inside Turns and 2 Wires on each side of Vent, to be Soldered but no Clips.

The Sketch to the Left Shows the Improper Arrangement of Band Wires Which Caused Excessive Heating of the Armature. The Other Sketches Show the Proper Method of Placing Band Wires on Armatures With and Without Ventilating Ducts

---

The Wage Decision.—Naturally the railroads cannot pay this increase out of revenues which are not sufficient to pay present expenses. Naturally, also, there is but one way to secure sufficient revenue, and this is to increase rates—freight and passenger—especially freight rates.—*Charleston (W. Va.) Mail.*

Railroading Here and There



SWISS RAILROAD ENGINEERS OVERCOME GREAT OBSTACLES WITH PICTURESQUE RESULTS

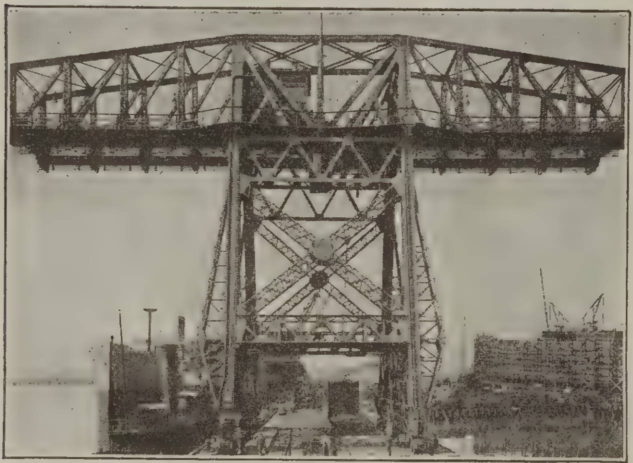
Electric Line Along the Visp River
The Great Stone Arch Near Brail
Railway Span Over the Wild Gorge of the Triege

An Interesting Section of the Martigny-Chamoinx Line
The Graceful Luegelkinn Viaduct on the Lotschberg Line
Arch and Tunnel on the Rhaetian Railway

Largest Electrically Propelled Gantry Crane

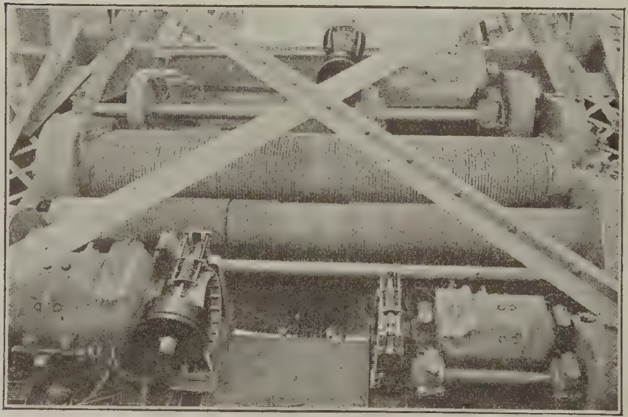
The Newark Bay Shipyard, Newark, N. J., offers an interesting example of the use of electricity for controlling cranes, as all the cranes and hoists are operated by electric motors.

This shipyard boasts of the largest electrically propelled gantry crane in the world. This crane is used for transferring material between the cars stationed on the bridge and the boats in the slip on either side. The crane is equipped with two hoists, the main hoist being driven by a 75 hp. motor, and the auxiliary hoist by a 50 hp. motor. The third motor controls the trolley motion. The hoists are equipped with C-H Type "M" brakes, while the main hoist motor has a special double brake with two releasing magnets. The bridge motion is obtained by four motors, two mounted on each supporting trestle in a position not far from the driving wheels.



Gantry Crane for Transferring Material Between Boats and Cars

The control panels are located in the small corrugated sheet iron house at the top of the crane and the four drum master controllers, which actuate the switches on the control panels, are located in the operator's cab below.

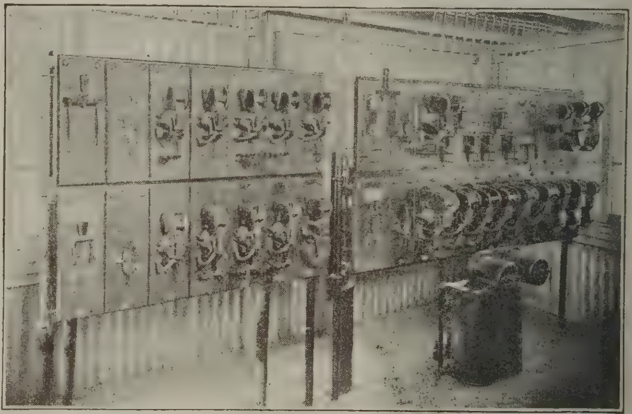


View of Trolley of Gantry Crane Operated by Motors Equipped With Electric Brakes

Each master controller controls one of the following through its own control panel: main hoist motor, auxiliary hoist motor, trolley motor, and the four bridge motors.

The panel controlling the four bridge motors has a drum reversing switch, operated by means of two solenoids, and located on the floor below the panel. Both hoist motors are slowed down by means of dynamic braking, and are brought to a final stop by means of the brakes.

Associated with the bridge motors and their control panel are rail clamps, which hold the crane to the rails when stopping, to prevent wind or other disturbing agencies from moving it, and to prevent the crane tipping when brought to a sudden stop. The rail clamps are set and released by means of four motors, two located at the bottom of each trestle. When the bridge master controller is moved to the "off" position, the four motors are slowed down and brought to a stop by means of series brakes, following which the rail clamps automatically set, thereby holding the crane in position. If the controller is suddenly reversed to change the direction of the bridge motion, the crane will come to a stop, the rail clamps will set, then release, and the crane will start in the intended direction. This cycle of operation is repeated whenever the direction of motion of the crane is changed. When the crane is at rest, the bridge master controller is in the "off" position and the rail clamps are set, hence preventing any movement of the bridge until the operator moves the lever of the master controller. A red and a green pilot light in the operator's cab is used in conjunction with the rail clamps. The red light indicates that the clamps are set, and the green light that they are released. All control apparatus used in the operation of the crane was furnished by The Cutler-Hammer Mfg. Co., of Milwaukee and New York.



Auxiliary Hoist Motor Control Panel on Left, and Control Panel for Four Bridge Motors on Right. A Solenoid-Operated Reversing Switch is Mounted on the Floor on the Right.

This installation affords a good example of the flexibility of electric control on cranes and the ease with which the different controlling movements can be made. Electricity is used on this installation, however, for other purposes than automatic control, as is evidenced by the statement of the crane operator when the views were taken: "You have missed the most popular and important electric installation—the electric space heaters, which keep my cab warm."

Principles of Car Lighting by Electricity

A Course of Practical Lessons Explaining the Main Details of This Important Application

By Chas. W. T. Stuart

II. Head End System

THE "head end" system is a system with a generator located at the head end of the train to furnish power for lighting the entire train. This system had its beginning about 1887 and developed into several methods:

1. Generator in baggage car driven by belt to car axle.
2. Generator on locomotive driven by steam turbine.
3. Generator in baggage car driven by steam turbine or gas engine.

Fig. 1 is a diagram of a four-car train with the lighting circuit of each car connected to the generator.

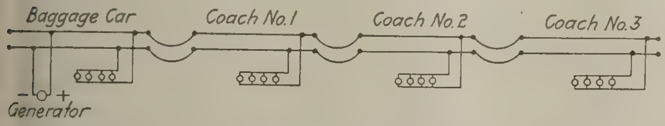
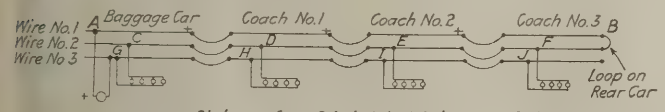


Fig. 1.—Generator in Baggage Car and Driven By Steam Turbine

You will note in Fig. 1 that only two wires are shown from the generator to the extreme end of the train. While two wires would complete the circuit, it is not a practical arrangement and is given here as a matter of simplicity for illustrating. If only two wires were used in the train line with no other apparatus, as shown in Fig. 1, the lamps in the various cars would not burn with a uniform brilliancy. The car nearest the generator would have the brightest light. For example, if there was a sufficient lamp load to give a five-volt drop in the train line of each car, with a voltage of 65 at the generator, Fig. 1, coach No. 1 would receive 60 volts, coach No. 2 would receive five volts less or 55 volts, coach No. 3 would receive five volts less than coach No. 2 or 50 volts. To overcome this unbalanced condition, the three-wire train line is used. The three wires are connected so that the lighting current for each car travels through the same length of wire. If the circuit to each car contains an equal amount of wire the voltage drop to each car will be the same, resulting in the lamps in all cars throughout the train burning with an equal brilliancy. This is illustrated in Fig. 2, which shows a diagram of a four-car train with a three-wire train line. Wire No. 1, Fig. 2, runs from the generator to the rear of the train, where it is connected by a loop to wire No. 2. Wire No. 2 feeds the positive side of the light circuit on each car. Wire No. 3 connects the negative side of each light circuit with the negative side of the generator. By using the distances between points, as given in Fig. 2, let us figure the number of feet of wire the current travels through for lighting each car, and then prove that it is equal. Starting at the positive side of generator, the current for lighting the baggage car will travel from point *A* to point *B*, then to point *C*, a distance of 150 plus 175 or 325 feet. The negative side of the light circuit of baggage car and the negative side of the generator are one, so that the total amount of train line wire which the current for lighting the baggage car travels through is 325 feet. The current for lighting coach No. 1 travels from point *A* to point *B*, to point *D*, returning from point *H* to point *G*, a distance of 150, plus 125 plus 50 or 325 feet. The current for lighting coach No. 2 travels from point *A* to point *B*, to point *E*, returning from point *I*



Distance from Point A to Point B = 150 feet
" " " B " " F = 25 "
" " " F " " E = 50 "
" " " E " " D = 50 "
" " " D " " C = 50 "
" " " J " " I = 50 "
" " " I " " H = 50 "
" " " H " " G = 50 "

Fig. 2.—Three-Wire Train Line

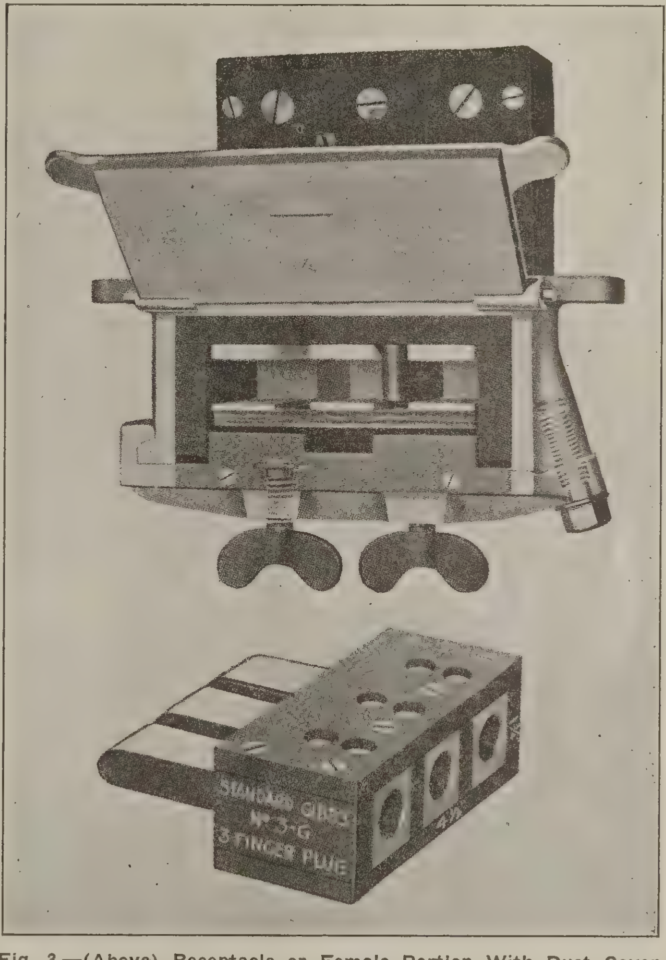


Fig. 3.—(Above) Receptacle or Female Portion With Dust Cover Open Ready to Receive Plug. (Below) Plug or Male Portion

to point *G*, a distance of 150 plus 25 plus 100 or 325 feet. Current for coach No. 3 travels from point *A*, to point *B*, to point *F*, returning from point *J* to point *G*, a distance of 150 plus, 25 plus 150 or 325 feet. This proves that the current for lighting each car travels through 325 feet of train line wire, and therefore the voltage drop to each car will be equal and the lamps throughout the train will burn with an equal brilliancy.

Method of Connecting Train Line Wires

While we are on the subject of a three-wire train line, there is another feature that can be explained, and that is the method of connecting the train line between cars. The Gibbs train line connector, Fig. 3, is in common use for this purpose. The female portion of this connector is fixed to each end of the car and connected to the ends of the train line wires, Fig. 4. The train line on one car is connected to the train line on the adjoining car by a train line jumper. This jumper consists of two male plugs connected together with three flexible cables, as shown in Fig. 5. The two outside train line wires are crossed on each car as a means of making the connections of the female connectors at each end of the car uniform. The uniform rule is positive terminal to the right facing the end of the car. This uniformity of connectors makes it possible to connect the train lines of the various cars throughout the train by using a standard train line jumper, and the cars may be placed in the train without regard to which ends of cars adjoin. To explain this more fully let us suppose that the train line wires on each car were not crossed, but instead, connected straight through, as shown in Fig. 6. Then facing the *A* end of each car, Fig. 6, the positive wire would be connected to the left-hand terminal of the female connector and facing the *B* end of each car, Fig. 6, the positive wire would be connected to the right-hand terminal of the female connector. This would work out successfully if you had the *A* end of one car connected to the *B* end of the adjoining car. But if, by chance, the cars were turned so that the two *A* ends adjoined, the wires would be crossed when the jumper was connected. To overcome this, the two outside wires are crossed on each car, as shown in Fig. 7, and when either end of one car is connected to either end of the other car, the connections are standard throughout.

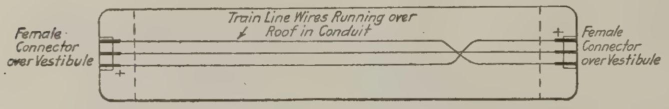

Female Connector over Vestibule
Train Line Wires Running over Roof in Conduit
+
+
Female Connector over Vestibule

Fig. 4.—Female Gibbs Connector at Each End of Car

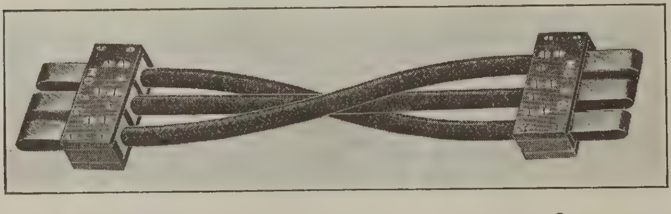


Fig. 5.—Train Line Connectors Used Between Cars

Next comes the applying of the train line jumper. The male Gibbs connector is designed so that it can be inserted in the female portion but one way, Fig. 7. The train line jumper is connected straight through as shown in Fig. 5, but when it is inserted between cars it is twisted so that the two outside wires are crossed again and the right side or positive side of the female connector of one car is connected to the right side or positive side of the female connector of the adjoining car, that is, the right side of each female connector facing the end of each car respectively, Fig. 8. Each female Gibbs connector is equipped with a loop or shunt which is operated either by hand or automatically. The function of this loop is to connect two of the three train line wires together, when it is desired, at various points in the train. The improved Gibbs train line connector is constructed so that the loop is made automatically when the plug is removed from the receptacle, and is opened when the plug is inserted. This automatic attachment also holds the plug in place and locks the automatic loop. The automatic loop female Gibbs connector is taking the place of the old hand loop type, as it provides a loop at rear of train, where a loop is needed at all times. Should a connector between the rear car and the dynamo car become disconnected from any cause, then the improved automatic loop completes the circuit and prevents the lights going out on the entire train. The Gibbs train line connectors are designed for the following ampere capacity—

No. 1 G 100 to 150 amperes 250 volts
No. 2 G 175 to 200 amperes 250 volts
No. 3 G 225 to 250 amperes 250 volts

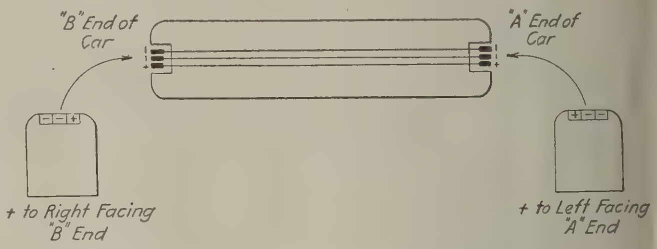


Fig. 6.—Wrong Way of Connecting Train Line Wires

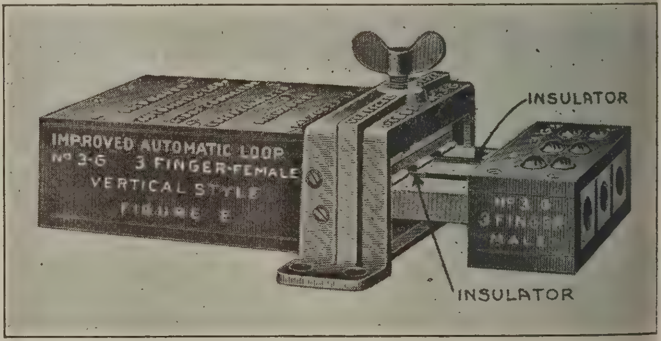


Fig. 7.—Plug Can Be Inserted In Receptacle In Only One Way Due to Arrangement of Insulation Between Fingers

So far we have described a head end system with a generator only for supplying the current to light the cars in the train. This is known as the straight head end system. With this system, when a train is disconnected for the purpose of cutting off cars, the cars in back of the disconnecting point in the train are thrown in darkness or, if anything happens to the generator, the whole train is thrown in darkness until the generator is repaired. Also, when the engine is not attached to the train to furnish the steam to drive the turbine, the train is in darkness. To overcome this it was found necessary to place batteries on the first and last cars of each train so that, if the generator failed, the batteries would furnish current to light the train, or if the train was parted to cut in or cut out cars, each section would have light. This system was a failure on trains with heavy loads, because of insufficient battery capacity. Consequently, batteries were applied to each car, which greatly increased the time that lights could be depended upon in case of the generator being out of service, and also made it possible for each car to have light when cut off individually. The addition of batteries to the head end system added another problem to solve and that was the charging of the batteries and particularly while the lights were burning. It takes a much higher voltage to charge a storage battery than the battery will give on discharge. Therefore, it was necessary to make some provision for protecting the lamps while the battery was charging. In dealing with this problem, each road developed a system to meet the conditions as they existed on its particular lines, which resulted in several different schemes of wiring, battery charging and operation. Today the standard three-wire system of wiring and standard connectors are used in making connections between cars and the wiring systems as a whole differ only in the method of charging batteries.

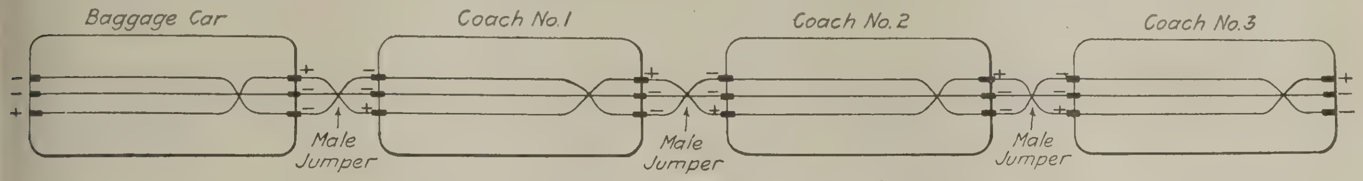


Fig. 8.—Correct Way of Connecting Train Line Wires

On the C. B. & Q., C. M. & St. P., Great Northern, and Northern Pacific roads each set of batteries is charged with its cells connected in series across the full generator voltage, and the resistance is cut in series with the lighting circuit to give proper voltage at the lamps, Fig. 9.

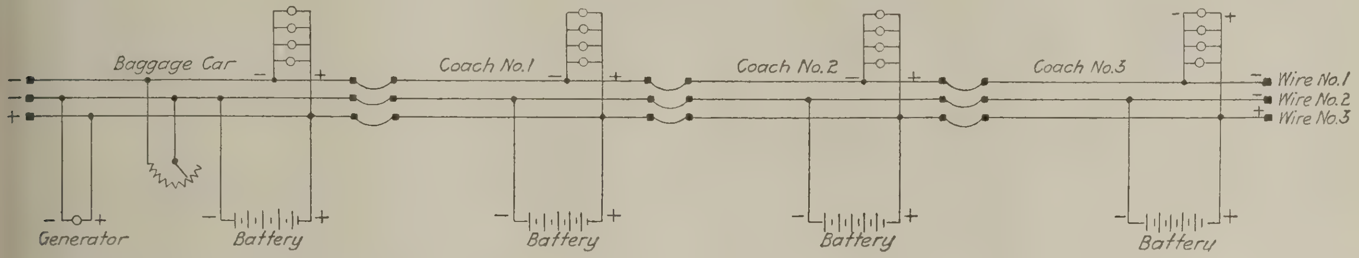


Fig. 9.—Batteries Charged Across Full Generator Voltage. Resistance Is Cut in Light Circuit to Give Proper Voltage at Lamps

On the C. & N. W. and Harriman lines the generator voltage is kept so that the lamps receive their rated voltage and the battery on each car when charged is split into two 30-volt sets, which are charged in parallel, in series with a suitable resistance. This changing of battery connections for charging is accomplished

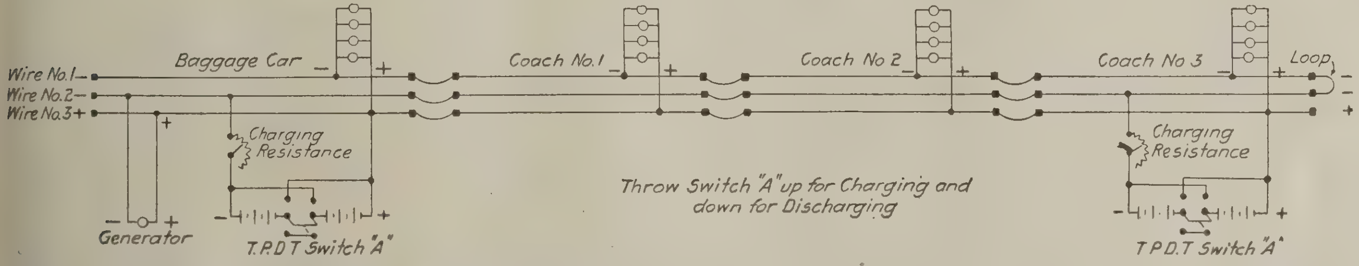


Fig. 10.—For Charging, the Battery Is Split Into Two 30-Volt Sets, Which Are Charged in Parallel, In Series With An Adjustable Resistance, the Generator Voltage Is Kept So That the Lamps Receive Their Rated Voltage

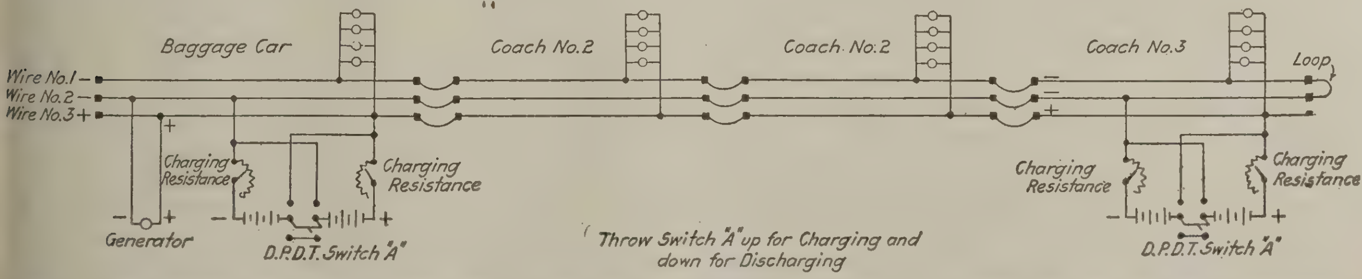


Fig. 11.—For Charging, the Battery Is Split Into Two 30-Volt Sets, Which Are Charged in Parallel, with an Adjustable Resistance In Series With Each 30-Volt Set

by means of a double-throw switch in each car, Fig. 10 and Fig. 11.

The disadvantage of the head end system is noticeable at junctions where trains are broken and made up again. This makes it necessary to equip a large proportion of cars on each train with batteries, which increases the capital and maintenance cost. This system also requires a high steam consumption by the turbine.

Alternating Current Theory and Practice

A Brief Practical Review of Basic Principles Prepared for Railroad Electrical Workers

By O. C. Callow

VIII. Induction Motors

THE turning motion or torque of an alternating current induction motor like all other motors, depends upon the action of a magnetic field upon current carrying conductors. The most simple form of an induction motor would consist of a magnetic field made up of say four poles having an iron drum mounted in the center of the field, free to rotate and with copper conductors arranged around the drum. Such a machine is shown in Fig. 1. The winding of the two horizontal poles 1 and 3 are connected to one phase while the winding of the vertical poles 2 and 4 are connected to a second phase making a two phase four wire machine. There are no electrical connections to the revolving member. The winding which is connected to the power supply is called the primary while the other portion is called the secondary. These terms are used since their action is similar to that of a transformer from which they are borrowed. The primary winding is usually on the stator or stationary part while the secondary winding is to be found on the rotor.

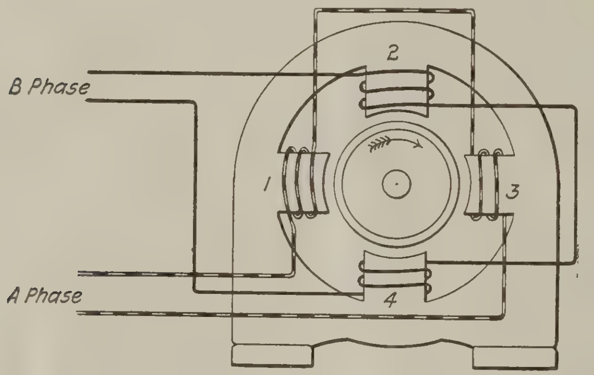


Fig. 1.—Elementary Two-Phase, Four-Pole Induction Motor, Showing Connections of Field Poles to Phases

The primary winding of an induction motor must produce a revolving field. A revolving field is a series of alternate north and south magnetic poles the positions of which are constantly changing in a given direction. Such a field might be produced by revolving permanent magnets or pole pieces, excited by direct current, around the rotor. It may also be produced by passing currents out of phase with one another through coils arranged symmetrically around the stator. These coils are usually connected in groups. The coils which are connected to one phase of the primary winding are so grouped that, if direct current were passed through them, north and south poles would be produced at several points of the stator. The coils in another phase are so grouped that north and south poles would be produced at an equal number of other points of the stator, differing in angular position from the first points. Alternating current will produce an effect similar to rapidly reversed direct current. A two or three phase alternating current is similar to two or three direct current circuits in parallel, the current direction of which is reversed at different instants.

If direct current were connected to coils 1 and 3 of the motor in Fig. 1 these poles would be north and south respectively, while if another direct current circuit were connected to coils 2 and 4, these poles would also become north and south respectively. If the current be reversed the north poles will become south and the south poles north. If the original connection be again made, the poles will return to their original polarity. It is this action which permits the north poles to continue to advance around the stator and the south poles to follow them when the coils are connected to a two or three phase circuit.

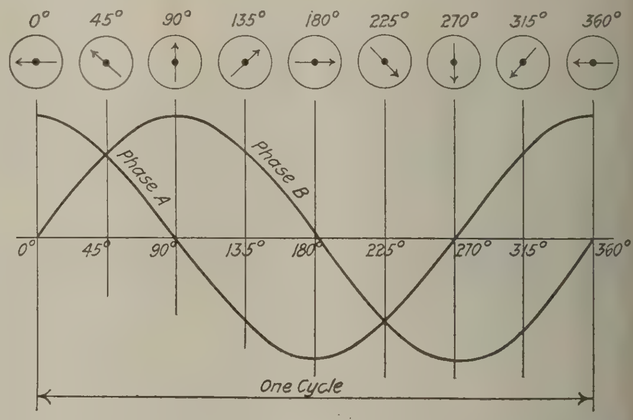


Fig. 2.—Illustrating Theory of Rotating Field of Two-Phase, Four-Pole Induction Motor, Showing the Various Positions of a Compass Needle Placed in the Stator Bore During One Cycle

In the machine in Fig. 1 the following changes will take place in the polarity of the field during one cycle:

Degrees	0°—90°	90°—180°	180°—270°	270°—360°
Polarity	1=N 3=S	2=N 4=S	3=N 1=S	4=N 2=S

Each time the current makes a complete cycle the magnetism advances 360 magnetic degrees. The machine in Fig. 1 has 4 poles, the magnetism will therefore make a complete revolution around the stator bore during 2 cycles. If the circuit has a frequency of 60 cycles per second, the magnetism will revolve at $\frac{60 \times 60}{2} = 1800$ RPM. This is the synchronous speed of a 4 pole motor on a 60 cycle circuit. The synchronous speed of an induction motor can be determined by the formula: $\frac{\text{cycles} \times 60 \times 2}{\text{number of poles}}$.

If a compass were to be placed in the center of the field poles of the machine in Fig. 1 in place of the rotor and the coils connected to a 2 phase circuit as shown, the needle of the compass would be seen to rotate in a manner shown in Fig. 2. The relation between this needle and the change of direction and strength of the 2 phase circuit is shown above by the curve, the time being one cycle. It will be noted that at 0°, phase *A* is at maximum pressure while phase *B* is at zero, hence the needle will only be affected by phase *A* which is connected to poles 1 and 3. It will therefore point towards pole 1, this being the north pole. At 45° the voltage in phase *A* will have fallen while that in phase *B* will have risen, the needle will therefore follow around in a clockwise direction until at 90°, the voltage in phase *B* being maximum, it will point upwards towards pole 2 which will now be a north pole, phase *A* being at zero will have no effect. At 180° the needle will again be horizontal and at 270° pointing downwards. It will reach its original position after rotating through 360°.

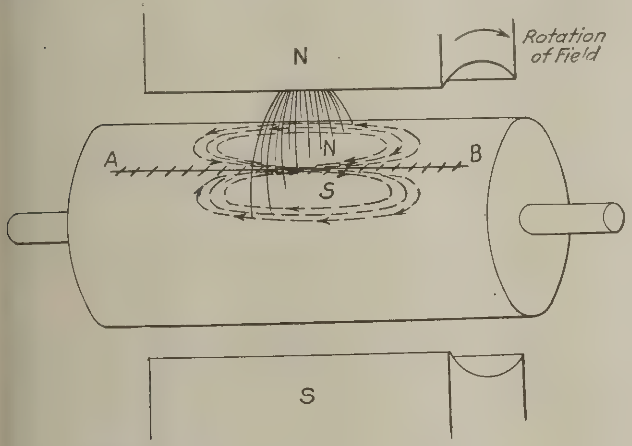


Fig. 3.—Distorted View of Two-Pole Induction Motor to Illustrate the Two Poles Induced in the Rotor by Eddy Currents Produced by the Magnetic Lines of Force From the N-Pole

We will now consider what effect the revolving field will have upon the rotor of the machine. For simplicity the rotor can be considered as a copper drum free to revolve between poles, the field of which is rotating in a clockwise direction. Considering pole 1 to be of north polarity at the moment of starting from rest, a section *AB* on the drum, Fig. 3, will cut the magnetic lines of force flowing out of the pole face. These lines of force will induce a current in this section of the drum whose direction will be towards *B*. Since the lines of force flowing out from the pole are strongest at the center the induced currents will be at greatest strength along *AB*, becoming weaker on each side. Accordingly, eddy currents will be set up along *AB*. These eddy currents will induce poles on each side of *AB*. By applying the right hand rule it will be found that south polarity will be produced by the eddy currents on the side of the drum receding from the pole while north polarity will be produced by the eddy currents on the side towards which the pole is moving. The drum is therefore attracted in the direction in which the revolving poles are rotating by the induced pole on the receding side and is repelled in the same direction by the induced pole on the approaching side. The drum therefore rotates in the same direction as the rotating field.

As long as the rotor revolves less rapidly than the revolving field, its conductors will cut magnetic lines and will thus have current generated therein. The faster the rotor revolves the less lines will be cut by the conductor and the lower the current generated. The speed of the rotor will be governed by the mechanical load on its shaft, since it must revolve slower than the revolving field to permit enough lines to be cut to generate a current which will react upon the revolving field and produce a torque equal to the mechanical load. Thus as load is placed on an induction motor, the rotor speed drops slightly so that more magnetic lines may be cut, producing more torque to meet the demands of the load. The difference between the speed of the rotor at any load and the synchronous speed or speed at which the field revolves is known as the *slip*. The slip of an induction motor at full load will vary from about 3 to 6 per cent, according to the size and design of the motor.

It has been shown in a previous article that a voltage is induced in any conductor which is under the effect of a variable magnet field; also that this induced voltage opposes the current which produces the variable magnetic field. The field set up in the stator of an induction motor is a variable magnetic field since it is produced by an alternating current. A countervoltage is therefore produced in the stator windings which opposes the impressed, or line voltage. Since this countervoltage is always smaller than the impressed voltage a current will flow through the stator winding sufficient to maintain the magnetism of same.

We have seen that more current is required in the rotor windings when a greater load is applied to the rotor shaft, brought about through an increase in slip. Since the rotor has no mechanical connection to the stator winding or line, we must see how this increase in current in the rotor is reflected back on the line. The conductors in the rotor will produce a magnetic field, which will buck the magnetic field of the stator or revolving field. It has been shown that the stator current is limited by the countervoltage induced in the stator windings by the stator magnetism, since the rotor magnetism bucks the stator magnetism it must lower it. Hence the greater the rotor current the lower the stator magnetism will become. Since the stator countervoltage depends upon the stator magnetism, this will be also reduced, resulting in heavier stator currents. Hence we find that increased load on the rotor shaft causes heavier currents in the rotor and stator, thereby drawing heavier currents from the line.

The principles of the induction motor can be summarized as follows: alternating currents set up a revolving field in the stator winding. Current is generated in the rotor winding by generator action caused by the rotating field. The rotor current reacts upon the stator magnetism and produces torque. Through transformer action the current thus produced is made proportional to the load.

In practice the stator winding of an induction motor is not wound on individual pole pieces like a d.c. motor. The punchings are arranged circular and are provided with slots on the stator bore. The windings are made up into coils and dropped into these slots in a similar manner to a d.c. armature. The different coils are then grouped together so as to give an equal number of poles in each phase, the number of poles having been determined by the required speed of the motor. The number of coils in a group and number of turns in a coil will depend upon the design of the machine and also to a certain extent on the circuit upon which the machine is to be operated.

The slots in the smaller motors are sometimes made partially closed and the turns of the coils are then slipped in through the slot, one at a time. Fig. 4 shows a connection diagram for a 4-pole 3-phase stator winding having 3 coils to a group. The connections between coils are made at the back of the coils and the leads are taken out at one point. It will be noted that the direction of current in each adjacent pole is different in order that the correct relation between north and south poles may be obtained throughout the entire winding of the stator bore.

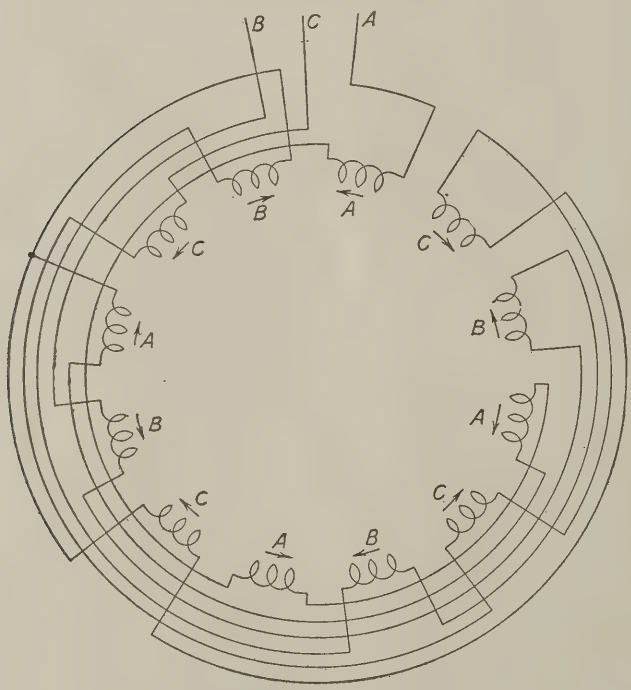


Fig. 4.—Connection Diagram of Stator Winding of Three-Phase, Four-Pole Induction Motor Having Three Coils Per Group

The induction motor is commonly made in two types known as the squirrel cage type and the wound rotor type. The stators of both types can be the same. The rotor of the former type has its conductors connected together at each end usually by welding or riveting to a copper ring. In some designs these conductors are placed in slots in the rotor punchings, running parallel to the shaft. This is the most common type of induction motor and is mostly used where a constant speed drive is required. The second type has its conductors arranged similarly to a d.c. armature in the form of coils, the ends being connected to slip rings. Brushes make contact with these rings and a resistance can then be inserted in the rotor circuit, which will enable the speed of the motor to be controlled at will, since an increased resistance will cause a larger slip. Higher torque at starting is thus obtained with a smaller starting current, which is a desirable feature.

Fig. 5 shows a performance curve of a 75 h.p., 3-phase, 25-cycle, 6-pole, squirrel cage induction motor. A study of this curve will show the relation of speed to output, the slip a full load being about 5 per cent. Special note should be made of the power factor and efficiency curves, which fall away very quickly at light loads. Hence the reason for advocating fully loaded induction motors in the previous article on power factor which appeared in last month's issue.

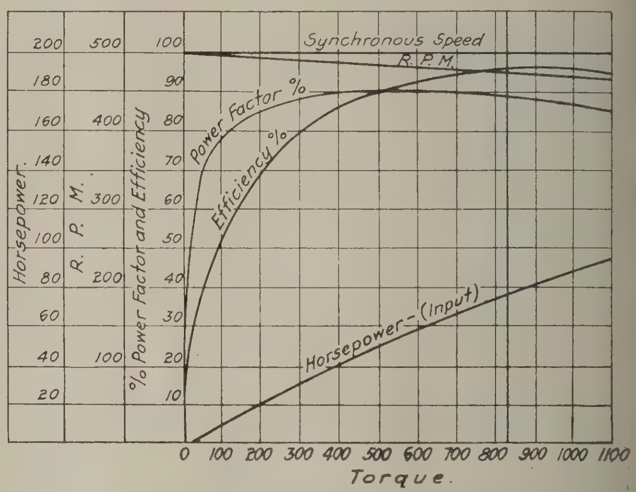


Fig. 5.—Performance Curves of a 75hp. Six-Pole, Three-Phase, 25 Cycle, Squirrel Cage Induction Motor

In operation the induction motor requires very little attention, having few wearing parts, especially in the case of the squirrel cage type. The voltages of the rotating parts are low so that little insulation trouble is encountered.

•• •• •• ••

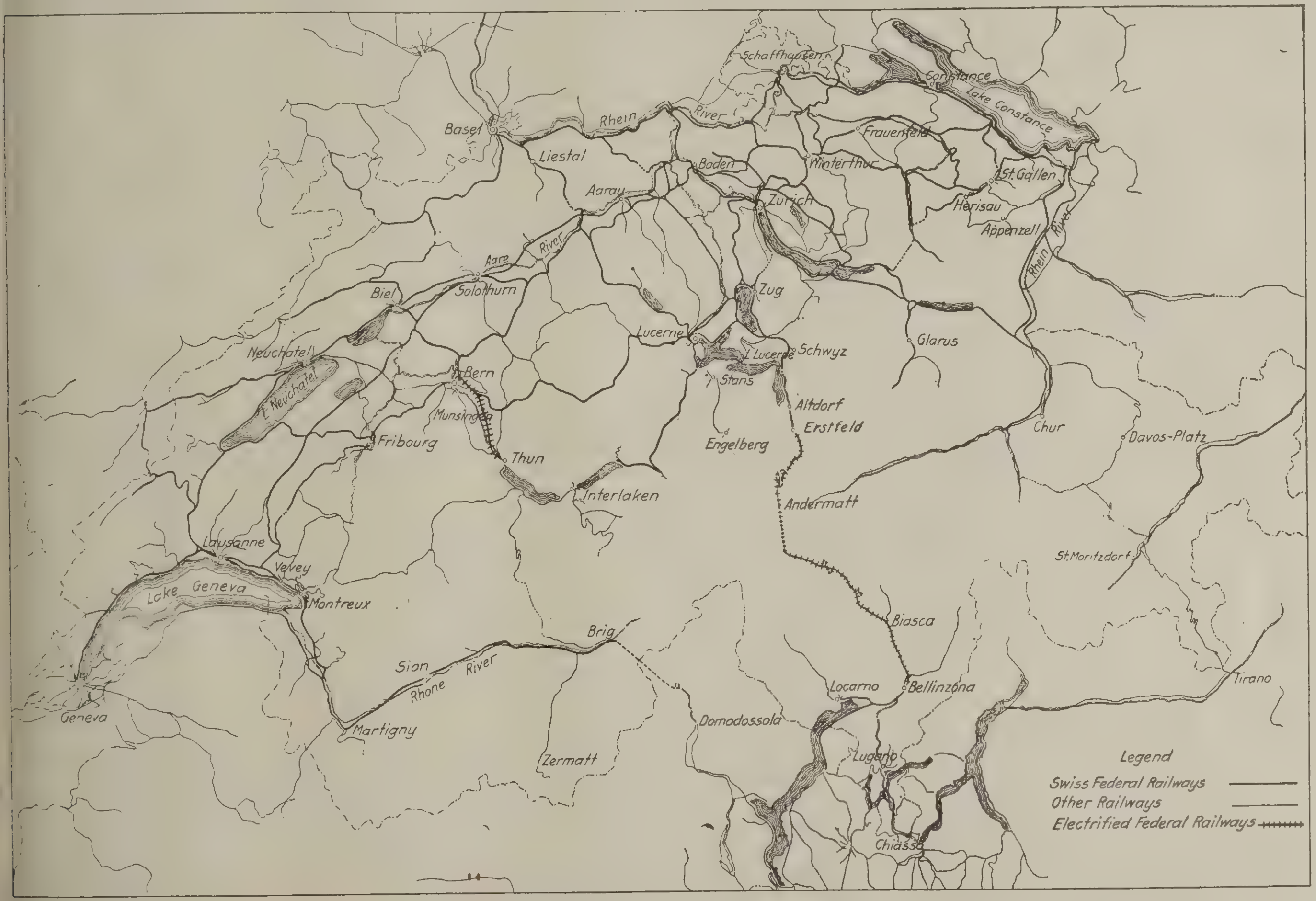
Photo Copyright by Kadel & Herbert, N. Y.

The Gare de L'Ouest at Paris, Idle Because of the Railway Strike

Electrification of Swiss Federal Railways

The Program Laid Out Will Eventually Include All of the Lines Operated By the Federation

ANOTHER big step has been taken in electrifying the Swiss Federal Railways. The Swiss Government has floated a $25,000,000 loan in the United States, consisting of 20-year, 8-per cent sinking fund gold bonds. The proceeds of this loan are to be used in the United States and the loan is a part of a program for the gradual electrification of the government railway systems of Switzerland. This is the highest coupon rate ever carried by a foreign government loan issued in this country. The last previous issue, which was a Belgian government bond, had an interest coupon of 7½ per cent. The issue of $30,000,000 of Swiss government bonds put out almost a year ago had a coupon rate of 5½ per cent, and at the offering price yielded to the investor a return of 6 per cent.



Principal Railways of Switzerland

The syndicate which offered the loan is headed by Lee, Higginson & Co., 43 Exchange Place, New York. The bonds were offered on Tuesday, July 6, and subscriptions were closed at noon on the following day.

The Swiss Minister of Railways has stated that it is not wise to wait the return of normal conditions before electrifying the railways, because the coal scarcity will probably last for many years.

Small Part of Federal Lines Now Electrically Operated

There are a total of 3,300 miles of railway in Switzerland, of which 1,900 miles are owned by the Swiss Confederation. These include the principal arteries of the Swiss railway system. Of the 1,400 miles owned by private companies, 622 miles are electrically operated. At present only two of the important federal standard gage lines have been electrified. The first was the line from Bern to Thun, a distance of about 20 miles, which was opened for operation in May, 1919. This line connects with the privately-owned Bern-Lötschberg-Simplon Railway and trains are hauled by electric locomotives direct from Bern to Brig. From 5 to 7 through passenger trains and 3 freight trains are operated each way per day over this line.

The second federal line to be electrified was the line from Erstfeld to Bellinzona, a distance of 68 miles. The electrification of this line was approved in 1913 and the work is now practically completed. This section, with 28 per cent of its length consisting of tunnels and a grade of 2.5 to 2.7 per cent for 25 miles, takes care of a large amount of traffic with Italy. It is expected that the electrification of this line will soon be extended from Bellinzona to Chiasso and from Erstfeld to Lucerne.

Power Supply

Efforts will be made to use a maximum amount of water power for the operation of the railroads. It is estimated that there is now available a total of 2,700,000 h.p. in water power and that if present plants were replaced with new ones and provisions made for controlling the headwaters that this might be raised to a total of 8,000,000 h.p.

Power for the Bellinzona-Chiasso and Erstfeld-Lucerne lines will be obtained from the power plants at Amsteg and Ritom. The Amsteg power house will afford 26,000 h.p. and the Ritom power house 32,000 h.p. and they may be used as the power supply of these lines even if the traffic increases 60 or 70 per cent.

In 1919 the Swiss Federal Railway accounts showed that the deficit had increased from $14,355,000 in 1917 to $41,510,000 in 1918. This was due to increased wages, pensions and the cost of all materials, but above all to the enormously increased price of coal during the last six months of 1918.

Equipment

All of the locomotives on the federal lines are designed to operate on 15,000-volt, low frequency, single-phase power supplied to them from an overhead wire. Four different types were delivered to the railroads in 1919. Two of these were ordered from the Ateliere de Construction Oerlikon, of Oerlikon, Switzerland, and two from Brown, Boveri & Co., Baden, Zurich. Each company supplied one passenger and one freight locomotive. The mechanical parts of all of the locomotives were supplied by the Swiss Locomotive & Machine Co., Winterhur, Switzerland.

The same method for transmitting power from the motors to the driving wheels is used on all four locomotives. The motor pinions engage gears on jack shafts, which in turn are connected to the driving wheels by side rods. The side rod arrangements designed by the two companies are distinctly different. The two Oerlikon locomotives are of the 2-6-2 and 2-4-4-2 type and weigh 91 and 113 tons, respectively. The two Brown, Boveri locomotives are of the 2-4-4-2 and 2-6-6-2 type, and weigh 118.5 and 133.5 tons, respectively.

Electric regeneration has been tried and found to be entirely satisfactory on these locomotives. This was the first practical application of regeneration to locomotives using single-phase series motors. The system first tried was that of the Maschinenfabrik Oerlikon.

The cost of electrifying the Erstfeld-Bellinzona Railway has been estimated to be $8,000,000 and the cost of electrifying all of the federal railways has been estimated roughly at $200,000,000. The satisfaction given by the American equipment will undoubtedly determine the matter of floating more loans for this purpose in the United States.

The Manufacture of Rubber Insulated Wire

Drawing Hard Copper Rods Into Wire is an Interesting Process—Mixing and Aging of Insulation

THE manufacture of copper wire from hard drawn copper rods into various sizes, and the protection of the wire electrically and mechanically after it is drawn, annealed, cleansed and tinned may seem to the layman simply a method of procedure; neither delicate nor intricate. Such a conclusion is only partly correct for there are some phases of the industry where the process is intricate and where the task at hand is delicate and most exacting. In general, however, the industry as a whole is a straightforward, understandable method of manufacture, which has advanced to its present high plane of perfection due to many years of research and development, together with the application of special machinery and special processes, each manufacturer employing the particular scheme of manufacture which according to his experience and knowledge of the art produces the results desired.

Drawing Copper Rods Into Wire

The drawing of wire into the various sizes begins with the preparation of ¼-in. hard drawn copper rods, for the stringer machine. The first operation consists of tapering one end of the copper rod a sufficient distance to allow for the proper spacing of the dies in the machine and the fastening of the starting end into the winding or coiling apparatus. The dies in this case are cast iron, usually four in number, and each one varies in size from the others, depending upon the diameter to which the copper rod is to be drawn in the machine holding the stringer dies. It is claimed that these dies last three or four months.

During the process of drawing the copper rod through the stringer dies considerable heat is developed and common soda in water is used as a cooling medium. From this machine the wire is drawn into the smaller sizes by passing it through diamond dies of the desired size. These dies last about a year. When the wire has been drawn to the proper diameter it is arranged in a convenient size coil and is then ready for the annealing oven. The device used for this purpose usually consists of apparatus which provides a means of carrying the wire to be annealed through water and oil, then without interruption through the annealing oven and out through water and oil. This process is continuous, although the movement of the coils through the machine is very slow. The temperature of the oven ranges from 800 to 1,000 degrees F., depending upon the size of wire to be annealed. The smaller the wire the lower the temperature.

After the annealing operation is finished the wire is wound on reels of convenient size preparatory to passing it through an acid (cleansing bath) and washing process. The next step is the tinning of the wire. This is accomplished by passing the wire through first one vessel of molten tin and then through another giving the wire two coats of tin. The second coat assures complete tinning of the conductor. The tin protects the copper from any injurious effect due to the action of the rubber compound. Copper wire is not tinned unless rubber insulation is to be applied.

Up to this point in the manufacture of copper wire the product is measured in pounds. From this point on, the wire is measured in feet and the stage in the process is reached where an insulating and protective covering can be considered. It might be of interest, however, to consider first the substance from which the rubber compound is made.

Some Facts About Rubber

"Up River Fine Para" is obtained from a white, feebly alkaline, watery emulsion, termed "latex," present in the living tissues of the bark, external to the cambium, of matured Hevea trees, growing wild in their natural habitat in the tropical forests along the Amazon and its tributaries. The parent substance, from which the highly nervy and elastic solid "Fine Para" is formed, occurs in the latex as a thick, oily liquid, so that in systematic classifications the latex would be styled an "Emulsion-Colloid," and to better appreciate the properties of rubber a general acquaintance with the nature of "emulsions" and "colloids" would seem to be both desirable and necessary.

A mixture of liquids insoluble in one another, where one is suspended in the form of minute globules, is termed an "emulsion." Counts of globules in Hevea rubber latex average 50,000,000 per cubic millimeter. The size of the globules in Hevea latex as it leaves the tree varies somewhat, depending on the season of the year, the age of the tree, the frequency and height of tapping, above ground, etc., but it may be considered as an average diameter of 0.001 mm., or 1/25,400 in.

The latex under high magnification shows the globules n a state of continual oscillation and in rapid, random or zigzag motion, a phenomenon termed "Brownian novement," after its discoverer, the Scotch botanist, Robert Brown, in 1827. This movement is a common property of all suspensions of very fine particles and is observed in cow's milk, as well as latex, in Missouri river water, in gas bubbles, in foam, in mist, in smoke, etc.

In addition to the globules of rubber substance, latex always contains varying amounts of resin and protein in uspension and various organic and inorganic salts, carohydrates and other substances in solution in the aqueus liquid. Without entering into the percentage amounts of these substances, it will suffice to state that the yield of rubber from normally good Hevea latex is about 40 er cent. The percentage of rubber in the latex is afected by the age of the tree, the manner and frequency f tapping, the dryness and wetness of the season, soil, tc.; and these same influences seem to affect the amounts of the other associated substances mentioned as constitunts of the latex. The daily yield of latex from a mature ree is stated to be about 1½ oz., which corresponds oughly to 5 lb. of rubber per tree, per season.

Certain soaps and many alkali salts of the higher fatty cids behave as crystalloids in alkaline solution and as olloids in neutral solution, while many substances which were hitherto assumed to possess a marked crystalloidal character, as common salt, gypsum, etc., can be transformed into the colloidal state, and even a typical colloid, such as white of egg, has been obtained crystalline. However, up to the present, rubber remains a colloid and has not been crystallized.

Liquids containing colloids show the "Tyndall effect" or scatter and polarize light in a direction at right angles to that of a beam of light passing through them, just as dust in air shows up when a beam of light is thrown into a darkened room. On the same principle the ultramicroscope has helped much in the study of colloids. Liquids containing colloids conduct electricity considerably less than solutions of crystalloids, which latter are, by contrast, strong electrolytes. It should be noted, however, that when an electric current is passed through an (electrolyte-free) colloidal "solution," some colloids migrate to the positive and others to the negative pole, showing that the former are charged negatively and the latter positively with regard to the solvent. Rubber latex, when treated in this way, rapidly becomes clear round the negative electrode. This is due to the rubber colloid being negatively charged with respect to the aqueous portion of the latex. Colloids have a marked tendency not only to stick to one another but also to foreign bodies. These are properties which the rubber man tries to avail of to their full extent.

"Coagulation" is clearly a colloidal problem, and without entering deeper into the theory of coagulation, which, when the term is applied to rubber, means changing the state of the globules in the latex so that solid rubber results. With fine Para, this extraordinary process is effected by the combined action of heat and smoke and is called "smoking." The latex exposed over a wood fire on which palm nuts (Urikuri) are burning, the smoke being rich in carbon dioxide, acetic acid, creosote and other substances, the effect of the protective protein is, as it were, neutralized, polymerization takes place and complete coagulation results. Though this process may be considered crude and primitive, the fact remains that some of the apparently more scientific ways that have been suggested to replace it have yet to turn out rubber the superior of fine Para.

Since Goodyear's time it has been known that rubber in the presence of sulphur, heated for an appropriate time, somewhat above the melting point of sulphur, experiences a profound change for the better in many of its characteristics. To the technical application of this important operation is given the name "vulcanization"; and though now we may understand a little more about the process, no revolutionary changes, apart from modifications in method, have been wrought in the procedure from the original plan as outlined by Goodyear. True, substances other than elementary sulphur have been tried out; progress would demand that, but all have been found wanting. Even in sulphur chloride, which has a limited use, sulphur has no worthy rival, as without it the vulcanizing effect is not attained; and though at one time or another sulphur has been blamed for all the ills that rubber may be heir to, it is usually found blameless when we have been able to discover the cause. Many theories, some of them indeed quite fantastic, have been advanced to account for the action of sulphur in rubber vulcanization. One is briefly this, that the action is mainly chemical and only in a small measure physical, that heat depolymerizes the small plastic constituents of the rubber, a condition favoring the chemical combination of sulphur, that super-polymerization then occurs and the plastic constituents acquire properties somewhat on a par with or superior to those of the hypothetical elastic constituent. Of course, "accelerators" increase the velocity of reaction, their action being mainly catalytic, assisting and lubricating.

Drying rubber after washing is an all-important step in the factory procedure. Every ounce of rubber that enters into the composition of insulation is carefully washed and dried at moderate temperatures. At the temperatures and under the conditions prevailing in vacuum dryers, kilns or in any of the modern accelerated drying processes, rubber depolymerizes and becomes softened and otherwise degraded, while in the long period attending the old-fashioned air drying the rubber recovers from any fatiguing effects of the mastication it has undergone on the washing mills.

The Manufacture of Rubber Compound

The manufacture of rubber insulation begins with the selection of the proper quality of rubber, which in the best grades of insulation forms 30 to 33 per cent of the compound, the balance being made up of various mineral substances, including zinc oxide, talc, chalk, sulphur, and a few others. The mineral fillers give life to the rubber, as crude rubber alone cannot be worked properly; it would oxidize in time. A larger percentage of rubber would result in a reduction in the life of the insulation because it would oxidize and harden more quickly; a larger percentage of mineral matter would not combine well with the rubber, and the compound would not be so good electrically or mechanically.

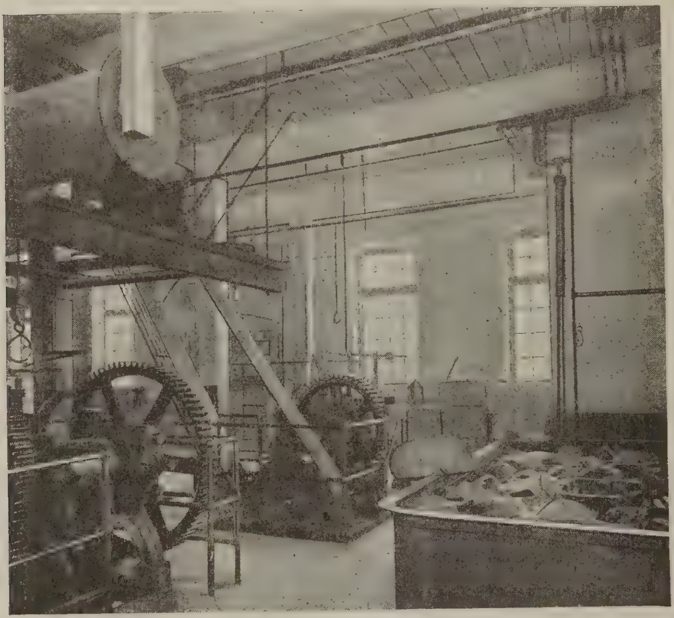


Fig. 1—Rubber Washing Room, Breaking Down Rolls at Left

"Up-River Fine Para" rubber before being used as insulation is thoroughly washed. This is accomplished by cutting the biscuits of the raw product, which weigh from 50 to 100 lbs., into smaller portions; these are then broken up by heavy rolls between which a stream of water flows. A view of the machinery used in this connection is shown in Fig. 1. This procedure removes the particles of bark, dirt and other foreign substances. The next operation consists of a continuation of the washing in another machine which forms the crude rubber into sheeting as shown in Fig. 2. These sheets of rubber are then hung in large rooms or chambers in which the air is warm and dry. One of these chambers is shown in Fig. 3. After drying and properly aging in this manner for six or eight weeks the rubber is ready for the compounding department.

The rubber sheets in the seasoned condition are cut into portions, and by weight are added to the other ingredients which have been weighed carefully, mixed and screened. The crude rubber sheeting is first broken down or masticated between two polished steel rolls; it is then mixed with the mineral ingredients, which are added gradually to the rubber on the mixing rolls so as to be well distributed and uniformly mixed. The compound is ground or kneaded over and over many times on separate sets of revolving steel rolls. This process forms the compound into very long thin sheets which are folded into bundles and allowed to rest for a few days so that the product may regain what is called its "nerve." Since there are no standard rules regarding the mixing, grinding, etc., each manufacturer uses his own judgment in having his practice conform with his experience and knowledge. These processes have an important bearing on the finished wire and its ultimate life. It stands to reason that an insulation that is correctly and uniformly mixed and thoroughly ground will be uniform throughout, free from imperfections and foreign material, and if properly vulcanized will have long life and excellent mechanical and electrical qualities.

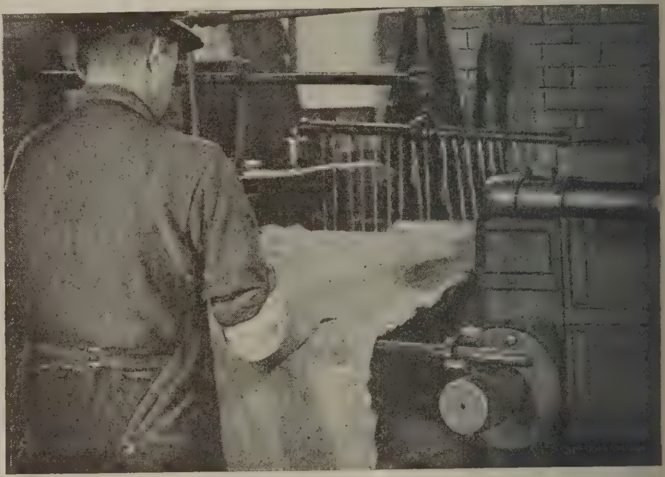


Fig. 2.—Sheeting Washed Rubber

Applying the Rubber Compound to the Conductor

In the application of the rubber compound to the tinned copper wire, several processes are in use. One method consists, of the seamless or spewing process in which the rubber is forced around the wire in a seamless tube by means of a screw machine operating in much the same manner as a sausage stuffer. The insulation is fed into the machine in strips and is forced around the wire at high pressure as it passes through the insulating chamber. The diameter is regulated by a die located where the insulated wire leaves the machine. The copper wire is held at the exact center of the insulation by means of a hollow steel leader. Another process is the strip method of insulating; the rubber compound is rolled or calendered to the proper thickness and is then folded or formed about the wire by grooved wheels which at the same time shear off the surplus rubber. Still another process consists of calendering the rubber compound on sheet tin. This particular operation is illustrated in Fig. 4. It may be of interest to elaborate to some extent the more important features involved in this method of insulating copper wire.

After the compound has been allowed a few days' rest, in order to season and regain its nerve, it is warmed and again rolled; this time to the proper thickness and then applied on sheet tin. The latter is obtained by rolling billets of tin into long sheets about 15 in. wide. These are surfaced and cleansed, then rolled up in a neat fashion on convenient spindles for application to three-roll calendering machines which are fitted with suitable tools for cutting the compound into the proper widths just before it is applied to the sheet tin. When the latter operation is completed the tin and compound are rolled up as shown in the lower section of Fig. 4. These rolls are then applied to another machine which cuts the compound, backed with tin, into narrow strips, and as the cutting operation proceeds the strips are wound on suitable spools.

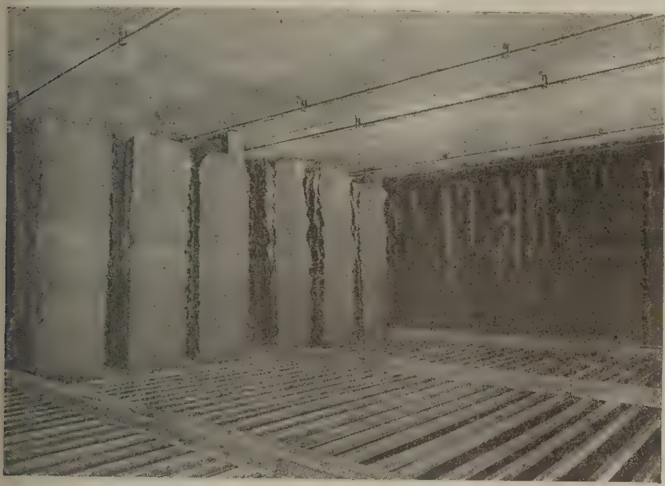


Fig. 3.—One Method of Drying Rubber in Rough Sheet Form

In order to make the strip continuous or sufficiently long to apply to a reasonable quantity of wire it is necessary to splice one strip to another. This is accomplished by removing a short section of the compound from the end of one strip and an equal length of tin from the strip to be joined, then the ends of the tin portions are butted together and the junction is soldered, following which the compound is replaced on the uncovered portion of the strip.

It is in this strip form that the compound is molded around the tinned copper wire. The method of applying consists of arranging the wire to be insulated and the tin covered compound in suitable apparatus so that when the machine is in operation the compound is molded around the conductor, lengthwise, with the tin on the outside. The die through which these materials pass is of such a shape that a ridge is left on the outer surface of the compound throughout its entire length.

When a greater thickness of insulating compound is required, the same general method of application is resorted to, except that the tin is stripped from the compound just before it enters the die or molding apparatus. Following this operation the next layer of compound is applied. This may be the final layer with the outer coating of tin depending upon the thickness of insulated wall required. It is claimed that this process not only insures perfect centering of the conductor but adds to the density of the compound, increases the tensile strength, prolongs its life and improves the electrical qualities. The conductor with its molded compound in place and the tin covering is wound on a suitable reel. It is in this shape and stage in the process of manufacture that the compound is vulcanized.

Vulcanization

After the rubber compound has been formed or molded around the conductor it is ready to be vulcanized. This is accomplished by placing the product into vulcanizing ovens. The exact temperature and duration of the vulcanizing process vary with the different manufacturers. Under-vulcanization results in a lifeless compound that is soft and won't last long. If the heat is carried too far there may be some volatilization which will ruin the insulation. This is a very delicate process, requiring a high degree of skill and experience, together with an accurate knowledge of the right temperatures and durations for the different grades of insulation, sizes of copper conductor and thickness of insulation. All these things must be considered and carefully worked out by the manufacturer. The process of vulcanization toughens the rubber compound and gives it life and elasticity. After vulcanization is completed the wire is removed from the vulcanizing ovens, and in the case of the tin covered product it is necessary to remove the tin. During this operation every foot of wire is tested electrically by means of a spark detector in order to note any defect in the insulation. The wire is then immersed in large tanks of water for a day or more for the purpose of making electrical tests such as insulation resistance, conductivity and voltage. The most modern testing instruments are

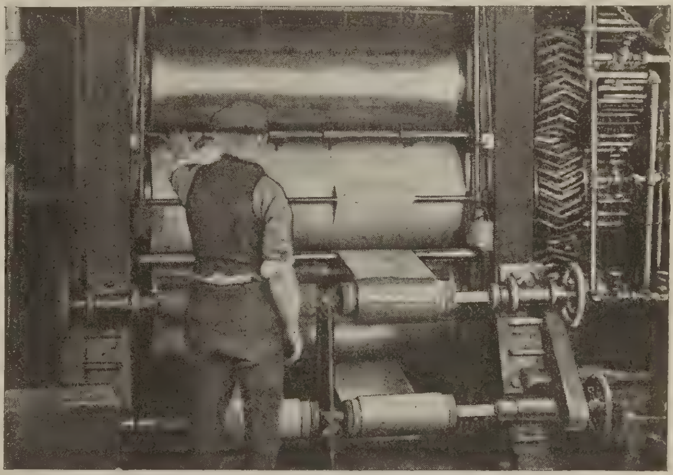


Fig. 4.—Calendering Rubber Compound on Sheet Tin

used and for high tension service high voltage equipment is applied.

Outer Protective Covering

Up to this point the conductor and its electrical protection has been provided. In most cases it is necessary to provide another covering known as the mechanical structure. This varies according to particular requirements. If tape is used as a covering between the rubber and braid it must be the right kind of tape. Some authorities consider that by its use the life of the wire is prolonged since the tape covering affords efficient protection from atmospheric influences, acid, water, alkalies, oil, iron, rust, etc. A weatherproofed or tar tape, or rubber saturated or friction tape will not do. These are porous and will admit moisture and hold it to the detriment of the rubber insulation. Such tapes would hold the iron rust particles, the oxygen in them being absorbed by the rubber, leaving metallic iron. The moisture converts this into rust again, which once more attacks the rubber, and this chemical cycle is repeated until the rubber is destroyed. But a good rubber-faced tape or calendered tape will not gather moisture. Such tape consists of thin, closely-woven cloth upon which is spread a thin film of rubber, which is forced into this cloth by steel rolls under a very high pressure. This tape hermetically seals the insulation from outside influences and gives the wire much longer life.

As stated in a previous paragraph the type of mechanical structure or covering for rubber insulated wire depends upon the particular requirements. In general, however, wire used in railway service has an outer braid covering. This may consist of one or more such coverings; the number depends upon the requirements. The material which is used in this connection is applied by braiding, weaving or interlacing the fabric as it unwinds from bobbins attached to suitable machines through which the insulated wire passes in an upward vertical direction. Some machines are equipped so that double braiding can be secured at the same time. Machines for making cable are usually of the horizontal type. Any variety and combination of colors can be obtained by using the colors desired. Stranded conductors are insulated and braided in a similar way. After the braiding is completed it is thoroughly saturated with a weatherproofing and preservative compound. This prolongs the life of the braid, protects the under cover of tape if any, and the rubber insulation surrounding the conductor.

From the brief description set forth in the preceding paragraphs it is an easy matter to realize that there is a very wide range in the manufacture of rubber insulated wire, particularly so when it is considered that both stranded and solid single conductors of various sizes are used and that the outer mechanical structure can be made up in a very large number of ways because of the many combinations available.

Multiple conductor cables can be made in infinite variety and for all purposes. Aerial cables are usually finished with one or two braids of cotton yarn saturated and coated with weatherproof compounds. Underground cables are almost always lead-encased, the lead being forced about the cable by hydraulic pressure.

For ornamental street lighting, steel tape armored parkway cables are used. This is an interesting development made to get away from expensive conduit systems, manholes, etc. The cable carries its own conduit, consisting of two spiral steel tapes wound over the lead-covered cable and protected by a layer of tarred jute. In installing these cables a shallow ditch is dug in the ground, the cable then being dropped in and covered over.

Such cables are sometimes laid inside the curb for sidewalk lighting or placed under the pavement in the gutter and led up into the lighting standards through holes drilled in the curb. This type of cable has been found useful in railroad yard work where there is danger of mechanical injury from dragging equipment or other causes.

Submarine cables are very often used for carrying current down bore-holes and shafts into coal mines and copper and other metal mines, the steel wire holding the weight of the cable.

Submarine Cables

For submarine cables, where the rubber insulation is removed from atmospheric influences, it is customary to use a 40 per cent Para insulation. The greater the percentage of rubber the greater would be the tendency to oxidize and harden the compound if the cable were exposed to air, but under the water this type of insulation seems to improve with age rather than deteriorate. Cases are known where submarine cables which gave an insulation resistance test of 4,500 megohms per mile at the factory, after being in service a few years, tested up to 6,000 and 9,000 megohms.

The original trans-Atlantic submarine cables were insulated with gutta percha, which is a gummy substance somewhat similar to rubber. Gutta percha insulation, however, is not as solid and firm as rubber insulation and as a result the copper conductor gradually works its way down through the insulation until it rests on the bottom. Cables today are insulated with rubber compound which after being vulcanized forms a practically waterproof insulation for the electrical conductors. Other types of insulation, like paper or varnished cambric, must be protected by a lead sheath if they are to be used in the presence of moisture. Deep-sea submarine cables consist simply of a stranded copper conductor, insulated with a good thickness of rubber compound, covered with a good rubber-faced tape, tarred jute bedding and a layer of galvanized steel armor wire.

The electrical industry is expanding so rapidly that new uses for rubber insulated wires and cables are coming up all the time. The manufacturer's engineers, however, are keeping ahead and are able to design the proper type of wire or cable to most efficiently serve the purpose for which it is to be employed. In this connection it might be well to mention locomotive headlight wire. By federal order all steam locomotives are required to be equipped with electric headlights. It would seem to be a comparatively simple matter to provide an insulated wire to carry the current to the headlight and the cab lights, but the condition makes it necessary to take into consideration the destructive effect of the excessive vibration, the extreme heat encountered where the wire crosses the smoke box on the front of the engine, moisture from steam and condensation, oil, grease and dirt. It is really a big problem to build a wire that will stand up for a suitable length of time under these severe conditions.

PRACTICAL STUNTS

A Few Maintenance Hints

By E. C. Meilloret, Electrical Repairman,
Morris Park Shops, Long Island Railroad

It not infrequently happens in repairing wiring on a train lighting job that some unscrupulous workman will neglect to solder a splice. In the event of his being detected the most common excuse given is that the load will be light and that the splice has been made very good so that it is really not worth while starting a blow torch or heating an iron. Coming down to hard facts the real cause is that the workman is too lazy to light the torch and do the job as it should be done. It is needless to say that no splice should ever be allowed to go unsoldered, regardless of the amount of current or voltage.

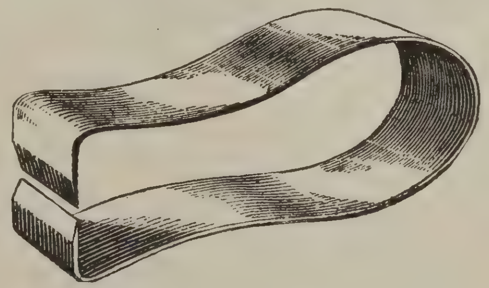
Although it may not be generally known, a very good job of soldering may be made with an ordinary coach candle. The splice must be clean and a very little soldering paste applied all over and the flame of the candle placed directly under the splice, a piece of wire solder applied and an excellent job will result. It is a very common mistake to think that a better job will result from using a large amount of paste. That is not so. It is only a waste of material and in these strenuous times when everything is so high it is the duty of every conscientious workman to help conserve any and all material. In the first place the wire should be thoroughly scraped, particularly if it is rubber covered, and both wires should be equally twisted, not simply one wire wound around the other. If this practice is followed a very little soldering paste applied to the splice will insure a perfect job.

Another error all too common is that made in skinning wires preparatory to making a splice. Trouble is almost certain to result when the insulated covering of the wire is removed by making a clean cut around the wire with a knife. Copper has the unfortunate property of breaking off sharply whenever it has been nicked or scratched with a knife or other sharp instrument. The proper way to skin the insulation off the wire is to cut the covering exactly as you would sharpen a lead pencil; if the work is performed in this manner little trouble ever results.

The care of commutators on axle driven generators, in fact on generators and motors of all types, is of utmost importance. Whenever it becomes necessary to sandpaper a commutator it should invariably be done with *sandpaper* and never under any circumstances with emery cloth. The glass used on sandpaper, which has been crushed and broken up very fine, invariably breaks up with blunt edges, though very sharp angles, and after the work has been done it simply falls off, or at least it can be blown away very readily. But not so with emery. It has a natural crystalline formation involving acute angles which seem to possess a perversity for digging into the mica sections. In this manner crevices are formed which collect copper and carbon dust, cutting the brushes and causing all kinds of trouble, usually starting with excessive sparking and generally winding up with a burnt-out armature. It is important to carefully wipe off all brushes after sandpapering, as any copper dust adhering to the end of the carbon brush causes the latter to heat unduly on account of its being slightly raised from the commutator.

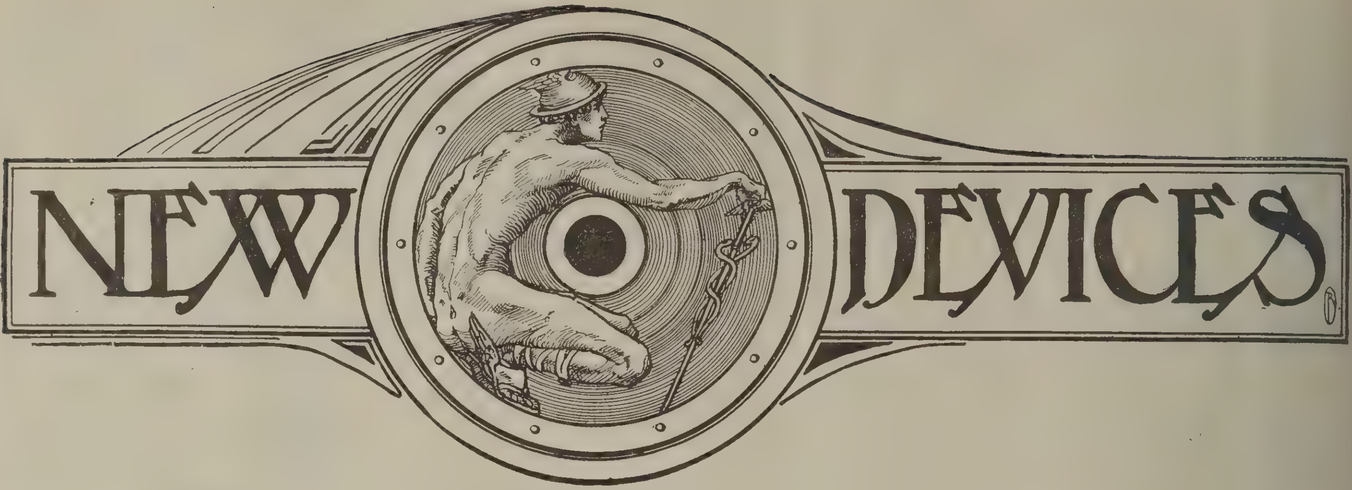
A Hacksaw Blade Makes a Handy Wire Scraper

Any old hacksaw blade may be turned into a wire scraper for use around a repair shop and in armature winding. Such an arrangement was described in a recent issue of *Power*. The illustration shows the completed scraper, which can be made from an old 12-in. hacksaw blade by grinding off the teeth on an emery wheel. Then, by using two pair of pliers for holding during the process of heating and bending, the blade can be bent into its proper shape as shown in the illustration. In order to heat the blade it is only necessary to hold it in the flame of a blow torch and heat to a dull red. Care should be taken to heat and bend only a small portion at a time and not to get the blade too hot. After it has been formed into its proper shape it should be cooled slowly in the air, not in water, and when cool the ends can be ground to a bevel, inwardly as shown. This tool is very handy for scraping solder from old commutator leads or for removing cotton insulation from new leads.



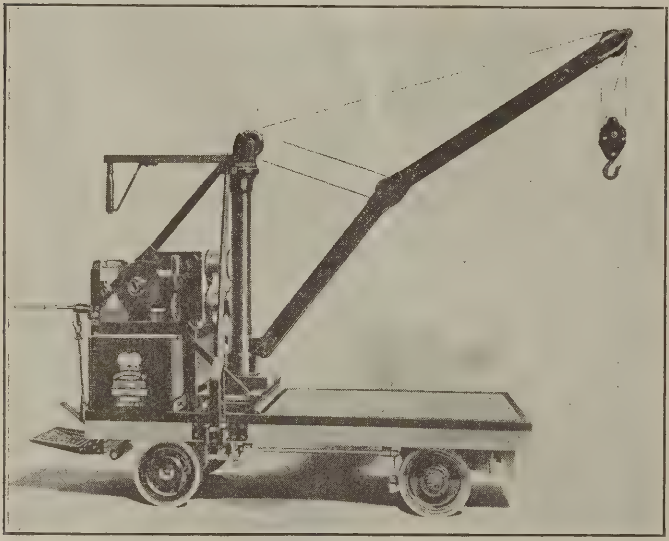
The Wire Scraper After Heating, Bending and Grinding

NEW DEVICES



Electric Crane Trucks

The Transportation Engineering Corporation, 200 Fifth avenue, New York, is offering its type "E" and "H" trucks, fitted with electric cranes of 1,000 and 3,000-lb. capacity. The 1,000-lb. cranes are furnished for hand or electric operation and are built in two different post heights, namely: 23 in. and 34⅝ in. and over-all heights of 70 in. and 84¾ in., measured from the platform of the truck.



Type "E" Truck Equipped with 3000-lb. Crane

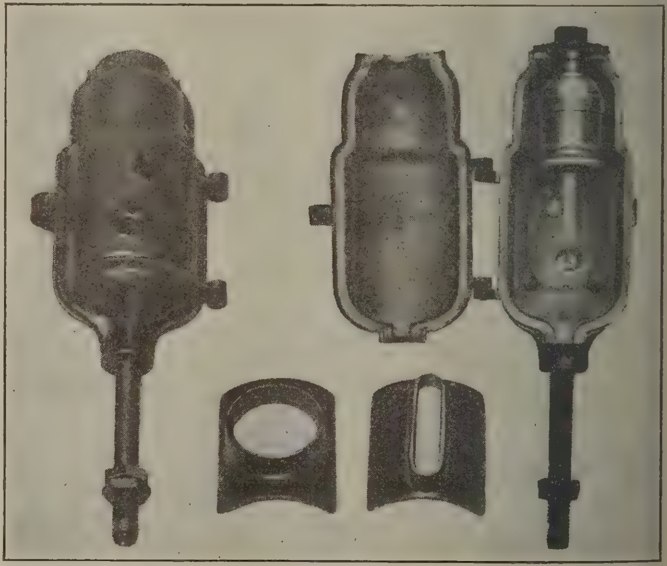
The 3,000-lb. electric crane is a recent development which has a compensating boom and is equipped with a swivel base so that the boom can swing through an angle of 180 deg.

The hoist and boom control are driven through a worm gear by a motor which is the same size as the one used for driving the truck. The boom is raised and lowered and the hoist operated by conveniently located controllers. A clutch is so arranged that one control only can be used at a time. In this way the possibility of damage resulting from interference of control is positively eliminated.

The truck is equipped with portable side arms, which when lowered prevent the truck from tipping when a heavy load is lifted on either side of the truck. Effort has been made to mount the crane so as to take up as little as possible platform space, thus making the truck serviceable for load-carrying purposes. All movable parts are bushed and provision is made for ample lubrication. The trucks are manufactured by the Automatic Transportation Company, Buffalo, N. Y.

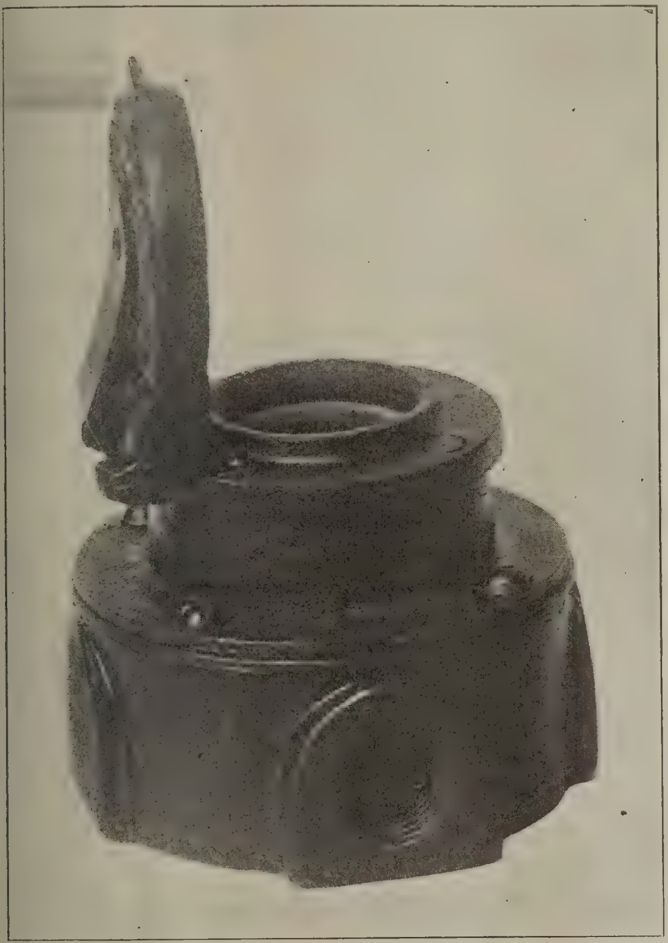
Two New Electrical Accessories

The American Metal Products Company, Brooklyn, N. Y., are marketing a universal gage lamp constructed of special non-corrosive cast metal. By the use of special visor plate with openings to suit various gage illumination, the number of lamps that it is necessary to carry in stock is materially reduced. The socket and top flange are in a semi-permanent position and may be removed when required without interfering with the wire connections in any way. The half-opening of the lamp provides liberal space for inserting and removing the bulb. The cover is secured in the closed position with an especially strong spring latch.



Two Views of the Universal Gage Lamp—Also Two Styles of Visor Plates

The second illustration shows a receptacle box which is also being constructed by this company. The cover of this box is one of its unique features, being supplied by a double leaf phosphorus bronze spring which holds the cover either tightly closed or fully opened. This feature facilitates the removal or insertion of the plug with one hand, leaving the other hand free for support. There is a gasket between the cover and the box so that when the cover is closed a perfectly tight joint results. A special composition gasket, which grips the plug when in service, forms a weatherproof joint. Four rugged bosses which can be tapped for ½-in. or ¾-in. conduit are cast on the base of the box. The receptacle is of the regular screw-base type.

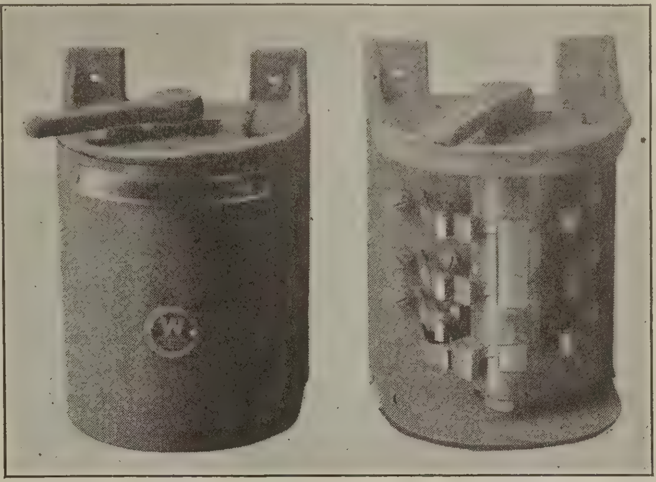


Waterproof Receptacle Box

Drum-Reverse Switch

The 809 drum reverse switch, manufactured by the Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa., is designed especially for starting and reversing small alternating and direct current motors driving auxiliary apparatus on almost all equipment in railway repair shops. It is also serviceable wherever a totally inclosed, double throw, two or three pole switch is desired. The maximum horsepower for direct-current service is as follows: 115 volts—2.5 hp.; 230 volts—5 hp.; and for alternating-current service: 110 volt—2.5 hp. and 220 and 440 volts—5 hp.

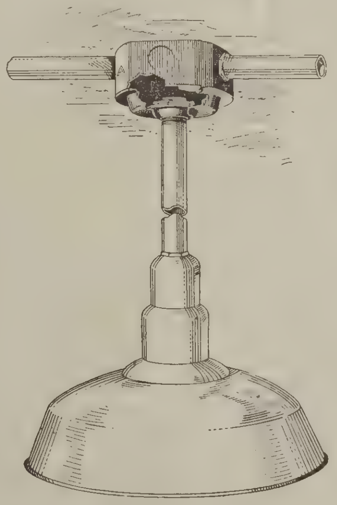
Arranged for suitable mounting on the machine base, the reverse switch is of compact construction. It is simple and rugged, neat in appearance and arranged for conduit wiring. All live parts are protected from accidental contact by means of an inclosing cover of sheet steel, lined with asbestos. The contacts, both fingers and drum segments, are of hard-drawn copper and brass, rated liberally to assure long life. The cover is easily removed to allow inspection and any adjustments that may be necessary. This switch is especially adaptable for connecting small alternating-current or direct-current motors directly across the line.



Drum Reverse Switch With and Without Cover

A New Swivel Fixture Cover

The Appleton Electric Company, Chicago, has designed a new swivel fixture cover for use with either 4-in. round or octagonal outlet boxes, which cover accommodates ½-in conduit. The swivel feature enables the fixture to hang correctly even though the outlet box be installed at an angle or the fixture be jarred in any way through accident.



Installation Using Swivel Fixture Cover

With the old method of using covers having stationary hubs or with lock nut and bushing connection, it was often possible that the fixture would not hang correctly after a time, naturally detracting from the appearance of the installation, as well as cutting down the efficiency of lighting.

General News Section

The Electric Storage Battery Company, Philadelphia, Pa., has increased its capital stock from $18,000,000 to $30,000,000.

The Alphaduct Company, 136 Cator avenue, Jersey City, N. J., has filed plans for an extension to its plant at 33-35 New street.

The Wagner Electric Manufacturing Company, St. Louis, has established a general service station at 501 Broadway, Milwaukee, Wis., in charge of **S. B. Moyer.** The sales office in the First Wisconsin National Bank building, Milwaukee, under the management of **F. T. Coup,** will be continued.

The American Insulator Company, New Freedom, Pa., with sales offices at 30 Church street, New York City, and Detroit, Mich., announces the opening of another factory at Norwalk, Conn., in addition to expansion in production capacity at New Freedom, to meet the requirements of its rapidly increasing business.

The Electric Tool Manufacturing Company, Petersburg, Va., has purchased the business of the American Electric Tool Company, including patents, manufacturing equipment, good will, etc. The complete line of electric hammers will continue to be manufactured on a greatly increased scale. **Louis Paulero** will remain in charge as chief engineer.

Until a few weeks ago two fans employed to rid a tunnel of the C. & O. railroad at Big Mound, W. Va., of gas and smoke were driven by steam power at the eastern end of the tunnel. Under the direction of J. M. Wilson, manager of the Virginia-Western Power Co., at Hinton, W. Va., electric drive has been substituted, and the fans are now operated by two 350-h. p. motors installed at the western end of the tunnel.

John F. Gilchrist, president of the **Federal Electric Company,** in an address delivered at a recent housewarming at the company's new plant, Eighty-seventh and State streets, Chicago, announced that plans were in contemplation under which employees would have a voice in the management of the company. Mr. Gilchrist told the employees that they could purchase stock in the company at almost any terms convenient to themselves, and said he was pleased to observe that approximately forty per cent of the employees were already stockholders. More than a thousand persons were guests at the housewarming, which was celebrated by numerous amusement features and a luncheon.

The Roller-Smith Company, 233 Broadway, New York City, announces recent changes in its sales organization as follows: **G. L. Crosby**—previously sales manager is now general sales manager at New York City. **M. Frankel**—previously assistant sales manager is now western sales manager at Chicago. **W. J. Shire**—previously a sales engineer is now eastern sales manager at New York City. **C. G. Kahant**—previously a sales engineer is now export manager and district sales manager at New York City. **F. R. Ryan, H. D. Baker** and **J. E. Wood** remain district sales managers, respectively, of the Chicago, Cleveland and Detroit territories. In addition to the above **C. M. Hunt** is a sales engineer in the New York Office and **M. B. Mathley** is a sales engineer in the Chicago office.

The National Carbon Company of Cleveland and San Francisco has recently increased the scope and efficiency of the Columbia Data Sheet Service for users of motors and generators. The data sheet furnished has twenty blank spaces in which the user indicates whether the brushes are needed for a generator, motor or rotary converter, also the service for which it is used, whether the current is direct or alternating, the name of the manufacturer, the type and serial number of the machine, voltage, capacity, load, measurements and so on. From these data in connection with exhaustive laboratory tests it is possible for the National Carbon Company to furnish brushes best suited for the exact operating conditions. Through this service of investigation, analysis and specification, it is possible to guarantee satisfaction with these brushes. The service is at the command of any user, no matter how many or how few units he has.

Bill to Electrify Japanese Roads

Cable advices from Tokyo under date of July 7, received in banking sources in New York, say that a bill has been introduced by government in the Japanese Parliament creating the Imperial Electric Railway Company. The aim of the bill is to establish electrical power supply for railroads and to gradually convert steam railroads to electric. Capital will be 100,000,000 yen ($50,000,000), of which one-half will be invested by the government and its dividend will not exceed 10 per cent. In case not sufficient profit is made to warrant the paying of six per cent, no dividends will be paid on stock owned by government, but will be applied for dividend on the privately owned stock.

British Empire to Extend Wireless System

The report of the committee appointed by the British Government to formulate plans for the connection of all parts of the British Empire by wireless telegraph was recently presented. The report recommends the installation of wireless stations in various parts of the British Empire, these stations to be situated approximately 2,000 miles apart. The plan as laid out provides for two main routes. One of these wireless routes will be for receiving messages from Africa, while the other establishes communication between Asia and Australia. Both routes will have their first station at Cairo, Egypt. The post office department has nearly completed the first link of the first chain between Oxford and Cairo.

It is estimated that the cost of the several installations will be approximately $5,000,000 and it is further calculated that during the first few years of its operation there would be an annual loss of approximately $400,000.

Electric Locomotives for the Swiss Federal Railways

The first of the 14 electric locomotives ordered by the Swiss Government in the latter part of 1918 for the Federal Railways (Guebe Valley and Berne-Schwarzenbourg lines) has just been delivered by the builders, the S. A. Brown, Boveri & Cie, Baden.

The new locomotive has successfully passed the tests it was subjected to before acceptance. The locomotive develops 1,000 horsepower at a speed of 40 kilometers (24.85 miles) per hour. The maximum speed attainable is 60 kilometers (37.28 miles) per hour. Single-phase, 15,000-volt power is supplied to the locomotives by an overhead system.

Of the 14 electric locomotives ordered, seven were to be made by the Swiss Machine & Locomotive Works at Winterthur, Switzerland, and seven by the S. A. Brown, Boveri & Cie, Baden, Switzerland.

Super-Power Zone Project Receives New Impetus

The proposed super-power zone which was brought up for discussion at the mid-winter's convention of the American Institute of Electrical Engineers last February, has received new impetus by the signing of the sundry civil appropriation bill by President Wilson. This bill has made available a $125,000 appropriation to finance an investigation and report on the feasibility of the super-power scheme for the northeastern Atlantic seaboard. It is expected that a report will be rendered by July 1, 1921.

The work will be under the supervision of the United States Geological Survey, of which George O. Smith is director. The engineering commission which will be created will consist of W. S. Murray, who is the originator of the present super-power plan, and a number of engineering associates. Mr. Murray has already been appointed chairman and chief engineer of the project and is authorized to appoint the balance of the staff.

PERSONALS

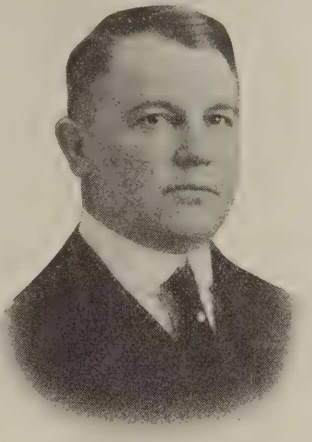
Robert C. Anderson, electrician first class, has been transferred from the West Shop of the St. Louis-San Francisco at Springfield, Mo., to Sapulpa, Okla., succeeding **E. N. Hughes,** transferred to Springfield.

A. L. Veith, electrician first class on the St. Louis-San Francisco at Monett, Mo., has been transferred to the car lighting department, succeeding **O. W. Cook,** resigned. **Glen T. Provo** succeeds **Mr. Veith** at Monett.

Lesley C. Paul, formerly editorial representative of the *Electric Railway Journal,* is now connected with the publicity department of the Westinghouse Electric & Manufacturing Company as technical editor in charge of railway publicity.

Mr. Paul has for five years been connected with the McGraw-Hill Company in circulation and editorial work and for the past three years he has been on the editorial staff of the *Electric Railway Journal* in the New York and Chicago offices. He is a graduate of the engineering course of the University of Colorado, 1915.

George H. Scott, electrical engineer with the O. K. Giant Battery Company, with headquarters at Gary, Ind., has been appointed representative of the Safety Car Heating & Lighting Company, New York, in charge of the northwestern territory, with headquarters at Chicago. Mr. Scott was born on June 6, 1880, in Pulaski County, Mo., and was educated in the State Normal School. He entered the service of the St. Louis-San Francisco at Springfield, Mo., on February 23, 1899, working in various departments of this road until 1906, when he was appointed foreman electrician, with headquarters at St. Louis, Mo. In December, 1907, he was appointed traveling electrician on the Chicago, Rock Island and Pacific, with headquarters at Chicago, and was later promoted to general foreman in the electrical department. He was appointed foreman electrician with the Pullman Company at Cincinnati, Ohio, on June 1, 1910, with which company he was employed in various capacities until his resignation the early part of this year, to become electrical engineer with the O. K. Giant Battery Company.


Geo. H. Scott

W. R. Stinemetz, who was recently appointed manager of the heavy traction section of the **Westinghouse Electric & Manufacturing Company,** East Pittsburgh, Pa., graduated from Lehigh University in 1893 as electrical engineer. In 1897 he became associated with the Westinghouse Electric & Manufacturing Company in the engineering school, leaving in 1899 to become electrical assistant to chief engineer of the Third Avenue Railroad Company, New York. In 1900 Mr. Stinemetz went to Mexico as electrical engineer for Braniff & Co. and after spending some time there he became engaged in making some special studies of motor flashing on the lines of the Boston Elevated Railroad Company. During 1903 and 1904 he was engaged in construction work in the installation of motors in the Pittsburgh Glass Company's plant. In 1905 he was sent to Atlanta, Ga., to

W. R. Stinemetz

superintend the installation of one of the early single-phase roads. The following year he was sent to Europe as a consultant with Westinghouse European engineers in Italy and France on single-phase railway installations. On his return in 1909 he was placed in charge of installations for the Westinghouse Company of the United States Government power house and sub-station for the Capitol building and grounds, Washington, D. C. In 1912 he became associated with the railway sales department.

W. B. Curtiss has been appointed assistant to **George E. Emmons,** vice-president in charge of manufacturing of the General Electric Company. Mr. Curtiss will act as the personal assistant to Mr. Emmons in matters pertaining to production in the factories of the company, including the plant in Schenectady.

Mr. Curtiss has been in the service of the company almost twenty-eight years. After completing the course in electrical engineering at Tufts College in 1892, he came to Schenectady as a draftsman in the data department, and on the consolidation of the general offices of the company about a year later, became an assistant to the late Frank G. Pratt, head of that department.

He was connected with the office of the manufacturing committee in 1902. Nine years later he was named an appraisal engineer, and from that time until the present has had charge of valuation work in connection with the physical valuations of the plants of the company.

H. R. Warnock

Harry R. Warnock, general superintendent of motive power of the Chicago, Milwaukee & St. Paul, has become associated with the Standard Stoker Company, New York, as vice-president in charge of the mechanical department, with headquarters at New York. Mr. Warnock was born at Newcastle, Pa., on July 16, 1870. He began railway work as a freight brakeman with the Pennsylvania Lines West of Pittsburgh in June, 1889, and later in the same year went to the Pittsburgh & Lake Erie as a brakeman. In September, 1891, he was promoted to locomotive fireman and later was locomotive engineer, which position he held until May, 1900. From that date until July, 1904, he served consecutively as engine despatcher, roundhouse foreman, and general foreman, resigning on the latter date to become master mechanic of the West Side Belt, Pittsburgh, Pa., where he remained until October, 1905, when he became master mechanic of the Monongahela Railroad. He remained in this position until September, 1913, when he was appointed superintendent of motive power of the Western Maryland, and on December 15, 1917, was appointed general superintendent of motive power of the Chicago, Milwaukee & St. Paul, with headquarters at Chicago.

OBITUARY

Russell A. Griffin, general sales manager of the National Pole Company, died on July 14, at his home of pneumonia. Mr. Griffin was well known in the telephone field and was for many years connected with the American Telephone & Telegraph Company and later with the Western Electric Company before going into the pole business.

TRADE PUBLICATIONS

Electric Tools, Carbon Brushes, Etc.—Gilfillan Brothers Smelting & Refining Company, Los Angeles, Cal., is circulating catalog No. 7 on its electric tools, carbon brushes and ignition parts.

Brushes for Electrical Machinery.—The Morganite Brush Company, 519 West Thirty-eighth street, New York City, has issued bulletin M.B.C. No. 1, in which it describes its different types of Morganite brushes for electrical machinery.

The Flexible Woven Cable Company, Boston, Mass., is distributing a small envelope folder entitled "Hard-service Flexible Woven Cable for Portable Drills and Other Extension Work." The pamphlet illustrates the rough usage to which extension cords are frequently subjected.

The Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has issued leaflet 3482 entitled, "Revolution in Ship Propulsion," which traces through the development of motive power for ships. Descriptions of geared steam turbine drive, steam-electric drive, oil-engine drive and the oil-electric drive are included in this leaflet.

"Metal Melting Pots" is the title of a new 2-page, 8½ x 11 illustrated leaflet descriptive of C-H Melting Pots, both portable and bench types. These heating pots are especially serviceable for melting lead, tin, solder, babbitt, etc., and maintaining these metals at the proper temperature. The heat may be controlled by means of a rotary snap switch or an automatic control device which maintains the temperature at the desired point. The leaflet is known as Publication 826.

Lighting Data.—The Edison Lamp Works of the General Electric Company, Harrison, N. J., has issued a series of thirteen bulletins on the general subject of lighting. The following is a list of the bulletin numbers and the subjects covered: 101, Maintenance of the Lighting System; 102, Effect of Color of Walls and Ceilings on Resultant Illumination; 103, The Lighting of Show Windows and Show Cases; 104, Artificial Daylight for Merchandising and Industry; 105, 110- vs. 220-volt Circuits from the Standpoint of Lighting Service; 106, Illumination and Production; 108, The Lighting of Office Buildings and Drafting Rooms; 109, Lighting of Schools; 110, The Lighting of Textile Mills; 111, The Lighting of Piers and Warehouses; 112, Light and Safety; 113, Edison Miniature Mazda Lamps, Standard versus Special; 114, Edison Mazda Lamps, Theory and Characteristics.

Railway Electrical Engineer

Volume 11 September, 1920 Number 9

Advance in Subscription Rates

To Our Readers:

The application of electricity to the steam railroad field in all its various departments has extended so rapidly in recent years that we find it necessary in planning for the coming year to very considerably enlarge our editorial program, including among other things quite an addition to the number of editorial pages. Increasing costs, however, and not this enlargement of our editorial program, are primarily the reason that makes it necessary to increase the subscription rate throughout the United States, Canada and Mexico to $3. The rate to subscribers in other countries will be $5 and the price of a single copy 35 cents.

The publishing business, like the railroad and all other businesses, has been subjected to large increases in its costs of production. There are, however, special influences affecting the publishing business about which we feel our readers should be told.

Publishers of newspapers and periodicals have suffered greatly from increases in the price of paper and from shortages in the amount of it available; probably few of our readers have any adequate idea of what the changes in the paper situation have meant to publishers. The white paper used by newspapers and periodicals constitutes one of the largest items in their cost of production. During the first six months of the year 1920 the expenditures for paper for the *Railway Electrical Engineer* and the other railway papers published by the Simmons-Boardman Publishing Company were *194 per cent* greater than in the first six months of 1919. This increase in cost was due only in a small degree to an increase in the amount of paper used. It was caused almost entirely by advances in the prices that we have had to pay. During the first six months of 1920 the expense of typesetting, press work, binding and bulk postage of our railway papers was 125 per cent greater than in 1919. During the same period the increase in the cost of the engravings used as illustrations in our editorial pages was 265 per cent.

These statistics indicate the increases which have occurred in our "manufacturing costs." We have also been affected by the same influences which have compelled business concerns of all kinds to increase the wages and salaries of their employees.

The practical necessity for an electrical paper specially designed to meet the needs of those who are interested in the application of electricity to the steam railroad field is now generally recognized; there will be a still greater need for this service now that electrical apparatus is coming into use in such large quantities in practically every department of the railroad. It will be our purpose constantly to improve the *Railway Electrical Engineer* and to develop the editorial contents in such a way as to fully meet the needs of electrical workers on the steam railways. We therefore not only confidently expect to retain all of our present subscribers at the new rates, but are looking forward to a steadily increasing number of regular readers.

Roy V. Wright,
Editor.

THE CONVENTION NUMBER

As has been our practice in past years, the *Railway Electrical Engineer* for October will be given over almost exclusively to the presentation of the reports of the several committees of the Association of Railway Electrical Engineers, whose twelfth annual convention will be held in Chicago at the Auditorium Hotel, October 18 to 22. It is believed that the greatest possible benefit is derived by our readers from this method of procedure, for it brings to their attention those problems which are not only pertinent to the electrical men in the steam railroad field, but which are of greatest importance just now in making for increased operating efficiency. Focusing, as they do, the best thoughts of many active minds rather than the ideas of a single individual, it is readily apparent that the committee reports are bound to reflect those practices which have proved to be the best over a wide range of application.

We have planned to have the October number of the *Railway Electrical Engineer* distributed somewhat earlier than the usual mailing date in order that readers who expect to attend the convention will have a copy of the committee reports before leaving their homes. This is particularly desirable, since it gives them an opportunity to familiarize themselves with the substance of the reports and be prepared for something more than extemporaneous discussion of the papers presented.

To those who find themselves unable to attend the convention the October number of the *Railway Electrical Engineer* will be most welcome, containing as it will the full committee reports. The November number will contain an account of the convention, together with abstracts from the discussion of the various reports.

It is our constant aim to be of the greatest service possible to our readers and we feel that in giving extensive publicity to the activities of the Association of Railway Electrical Engineers we are distinctly assisting each and every electrical man in the steam railroad field.

A CRITICAL PERIOD

The railroads are again on their own feet, the guarantee arrangements with the government having expired on August 31. The Interstate Commerce Commission was given the responsibility by the Transportation Act of seeing that the credit of the railroads was restored in the interests of the public. The Commission has given the entire situation very careful study and has authorized rates which in its opinion will meet the provisions of this act. Some of the states are blocking some of the new rates, but the larger number of them have realized the wisdom of the recommendations which have been made by the Interstate Commerce Commission and are falling into line. Whether the new rates will be sufficient, of course, cannot be fully determined until actual figures are available some months from now. The general opinion seems to be that they will be sufficient to restore the credit of the railroads, provided traffic conditions continue as they now are. During the latter part of August the railroads broke all previous records in the number of cars which were loaded and the rate at which they were moved, and with two or three months of good weather a record can be made, if labor difficulties in the mining field or at terminals do not upset the calculations.

The Labor Board has granted a good increase to the employees and the larger number of the railroads have promptly followed this up by increasing the salaries of the subordinate officers and foremen. Not everybody is satisfied and a number of points are still in dispute, but the Labor Board is apparently doing its best to adjust the difficulties as quickly and satisfactorily as possible. No very considerable increase in physical facilities can be made before the winter sets in, and the only way in which the abnormal traffic can be moved will be through the most thorough and intelligent co-operation on the part of every man in the service. If this can be obtained there is little question but what food and fuel can be distributed so that there will be a minimum of suffering this winter. If, however, any considerable part of the employees lay down on their jobs or do not put forth their best energies, there is likely to be a considerable amount of distress in some sections of the country.

SELECTION OF SHOP MOTORS

The problem of shop motor selection is on the face of things a simple one and is often regarded as such by the mechanical men. It is comparatively easy to pick out a motor that is big enough to run a certain shop tool or if the circumstances connected with the selection are at all complicated the manufacturers will furnish specifications for a motor which will be the right one for the job. Such information supplied by the manufacturer is usually accurate and can be relied upon.

On the other hand, it is not possible to acquaint the manufacturer with all the conditions which do or will attend the use of the motor. It is necessary from a point of view of maintenance to have a minimum number of types and sizes of motors in a shop. A minimum number of types and sizes means a minimum number of repair parts and a maximum of interchangeability. Too few types and sizes usually means that many of the motors are oversize and this results in poor power factor, which in turn results in reduction of power plant capacity and electrical efficiency.

It is also possible to select a motor with too narrow a margin of capacity. A motor which is just the right size for all the usual operations of a machine may overheat when used with machine set-ups which require much starting and stopping. With the possible exception of this last, these conditions apply to motors for group drive as well as individual drive motors.

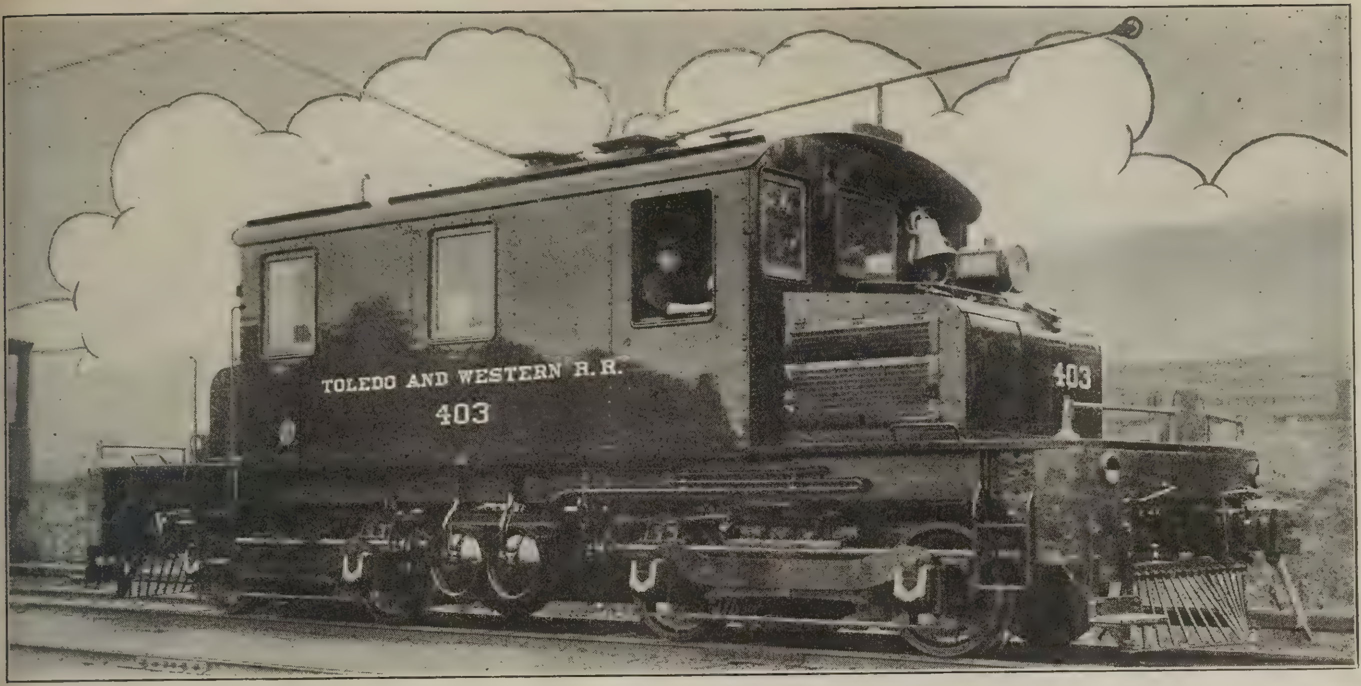
The matter of a minimum number of sizes and types for the entire road as well as for the shop must also be given consideration and in each shop there should be someone capable of working out the problems for that particular shop; someone who can in a measure anticipate future conditions and who is thoroughly familiar with the kind of work done and the practices common to that shop.

EXTENSION CORD FUSES

The ordinary extension cord is usually plugged into an electric light socket or some other suitable receptacle which is connected in multiple with other lamps and possibly other extension cords. Such a circuit is usually supplied from a panel box through fuses located in this box. It is obvious, therefore, if a short circuit occurs in an extension cord the fuse in the panel box will be blown and the service on this particular circuit will be disrupted. It would seem that smaller capacity fuses located in individual extension cord circuits would be a very desirable feature in preserving the continuity of the main supply circuit. A particular instance of the value of such an arrangement would be on a transfer platform where extension cords used for lighting purposes are carried into the various cars while the material is being loaded and unloaded. Without fuses in these extension cords, should any one of them become short circuited the entire platform is immediately thrown into darkness and the time lost is considerable, especially if there is no one about who is familiar with the replacement of the fuse. The same thing could very well be applied to extension cords in shops, possibly to even greater advantage, for under such conditions the cords are more likely to become damaged and therefore more liable to short circuits.

The idea presented can certainly not claim any great originality, for it is simply the practical and commonsense way in which the cords should be connected.

Are your cord circuits individually fused?



Standard Double Truck Electric Locomotive

For Switching Cars at Terminals This Type Possesses Many Advantages Over Steam Locomotives

By H. R. Horton
Railway Equipment Engineering Dept., Westinghouse Electric & Mfg. Co

At the present time when traffic is congested, sidings crowded, cars needed but standing idle because of lack of motive power to keep them moving, trunk line steam railroads, as well as interurban electric roads and even many private or branch railroads are looking for some relief from the situation. This situation is most serious at terminals owing to the lack of a sufficient number of switching locomotives and to the insufficiency of the required type of labor, not only for the operation of the locomotives but for maintenance, repairs and upkeep.

The value of electrification of terminals and even large sections of trunk lines has become so well recognized and has met with such marked success that no one doubts the ability of electric locomotives to help the situation. Unlike the steam locomotive, the electric locomotive may be operated almost continuously if need be, requiring overhaul periods of much less frequency than steam locomotives, thus doing two or three times the work of a similar size steam locomotive in the same kind of service. Realizing the need of electric locomotives for this type of service the Westinghouse Electric and Manufacturing Company in conjunction with the Baldwin Locomotive Works has standardized a line of locomotives to meet this service in yards of moderate extent. This standardization is the result of years of experience in building and perfecting locomotives through the study of the requirements and operation of the locomotives in this type of service.

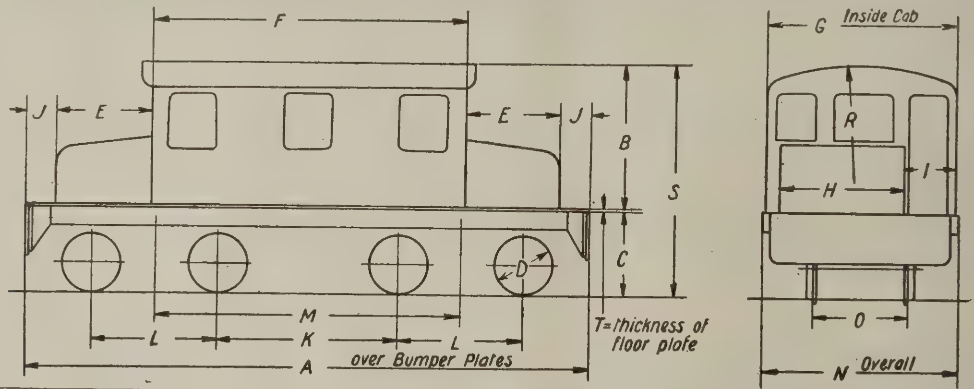
This standardization covers a range in weight from 25 tons to 65 tons with a normal horsepower rating of from 200 to 1,000 horsepower. The electrical apparatus is of the most modern type of tested and proved design resulting from years of careful study and improvement and covers a range in voltages from 600 volts d.c. to 1,500 volts d.c.

In the design of mechanical parts of these locomotives the operator's viewpoint has been kept in mind, resulting in a class of locomotives the wearing parts of which are interchangeable with standard railroad equipment as much as possible, and the complete detail design of which is based on the use of commercial sizes and shapes wherever feasible. Such parts as journal sizes, journal boxes, brake shoes, wheels, couplers, etc., conform to the Master Car Builders' and the American Electric Railway Association's standards. The steps, hand-rails, etc., are made to conform to the requirements of the United States Interstate Commerce Commission.

The present standard locomotives are classified as A, B, C and D, according to weight and to horsepower. Class A covers a locomotive with a range of from 25 tons to 35 tons, 200 to 360 horsepower; Class B, 35 tons to 50 tons, 380 to 700 horsepower; Class C, 44 to 50 tons, 480 to 1,000 horsepower, and Class D, 50 to 65 tons, 480 to 1,000 horsepower. Operating speeds up to 30 mph. are permissible, with a runaway speed of 35 mph. With slight modifications in design, arrangements for higher speeds where conditions require can be provided. Fig. 1 gives the general dimensions of the locomotives, while the photograph at the beginning of this article shows a completed locomotive ready for operation, from which an idea of the construction of the locomotive can be obtained.

Main Motors

The locomotives may be either low or high speed, with or without forced ventilation and field and regenerative control. The motors are geared directly to the axle, there being one motor for each of the four axles, thus utilizing the entire locomotive weight for securing maximum adhesion on the rail and high resultant draw-bar pull. The selection of the motor depends primarily upon the kind of service to be performed. For heavy switching service, maximum tractive effort at the least possible expenditure of current is desirable, which is obtained by the motors with slow speed windings. On the other hand, passenger service or fast freight service requires high starting tractive effort as well as higher speeds. These features are secured in the higher speed motors, particularly in the motors having field control. All of these locomotives are so designed that motors can be applied that will slip the wheels on dry rails well sanded, thus insuring maximum possible tractive effort and draw-bar pull.



Loco-motive	A		B	C	D	E	F	G	H	I	J	K	L	M	N	O	R	S	T
	Plate	C. I.																	
Class A	25'-8"	27'-4½"	7'-4"	4'-1⅝" 4'-2⅛" 4'-3⅛" 4'-4"	33" 34" 36" 33"	3'-5½"	14'-0"	8'-9"	6'-0"	2'-5½"	2'-4½"	7'-0"	6'-0"	13'-0"	9'-0"	4'-8½"	14'-0"	11'-6 ½" 11'- 7½" 11'-10½"	⅜"
Class B	29'-6"	31'-2½"	7'-6"	4'-4½" 4'-5½" 4'-6⅛" 4'-6"	34" 36" 37¼" 36"	5'-0"	16'-6"	9'-9"	6'-6"	2'-7½"	1'-8"	9'-6"	6'-6"	16'-0"	10'-0"	4'-8½"	14'-0"	11'-11" 12"- 0" 12'- 0⅝" 12'- 0⅜"	½"
Class C	32'-8"	34'-4½"	7'-6"	4'-6½" 4'-9" 4'-6"	37" 42" 36"	5'-0"	18'-0"	9'-9"	6'-6"	2'-7½"	2'-4"	10'-4"	7'-4"	17'-8"	10'- 0"	4'-8½"	14'-0"	12'- 0⅞" 12'- 3⅜" 12'- 0½"	⅜"
Class D	32'-8"	34'-4½"	7'-6"	4'-6½" 4'-9"	37" 42"	5'-0"	18'-0"	9'-9"	6'-6"	2'-7½"	2'-4"	10'-4"	7'-4"	17'-8"	10'-0"	4'-8½"	14'-0"	12'- 1" 12'- 3½"	½'

Fig. 1.—Outline Sketch With Table Giving the General Dimensions of the Locomotives in the Several Classes

Control

The control for these standard locomotives consists of the "H L" electro-pneumatic unit switch type. The most important advantages of this type of control are simplicity, protection against surges and overloads, easy operation from master controller and consequent safety to operator, powerful forces at switch jaws irrespective of line voltage, small number of wearing parts and easy replacements and repairs. A master controller is located in each end of the locomotive cab. The switch groups and other main parts of the control equipment are placed in a centrally located compartment surrounded by expanded metal screens which when removed allow very easy access to all vital parts of the control equipment for ready inspection. The air brake distributing valve is placed in this compartment, thus minimizing freezing and at the same time being very easily accessible. The wiring is all placed in metal conduit, thus insuring a minimum of troubles and a maximum of safety.

Air and Hand Brakes

The air-brake equipment consists of the most improved type of straight and automatic air-brake systems for electric locomotives having an unequalled record for reliability. This insures the same standard of air-brake equipment that is found in steam road operation. When required two air-compressor units are supplied especially for heavy service to insure an ample supply of air for braking and all other purposes. The automatic control of the compressors insures equal distribution of labor between compressors and also enables a single compressor to operate independently if desirable or necessary.

Hand brakes are also supplied for use in holding the engine when stored in yards or shops or at any place where air is not available.

Signal and Detail-Equipment

An air whistle of the "Clarion" type is supplied as standard, as is also an air-operated brass bell of standard size. "Leach" pneumatic sanders are provided at each end of the locomotive for sanding the leading pair of wheels. Headlights and trolleys are supplied in accordance with the requirements of the operator.

Mechanical Parts

The locomotive running gear consists of two four-wheeled trucks of the swivel type providing a sufficiently long wheel base to insure smooth riding qualities and to give equalized weight distribution and at the same time permitting the locomotive when operating in either direction to negotiate sharp curves and switches. The class A and B locomotives can negotiate curves of 35 feet radius without trailing load, and class C and D can negotiate curves of 40 feet radius. The minimum curve with trailing load is 90 feet when radial draws are applied.

The most important feature of any locomotive, particularly in these times of high costs of repairs and scarcity of labor, is the ability to withstand the severe service. A strong durable truck construction is essential for the high tractive efforts developed by these locomotives which calls for a very carefully designed truck and body underframing. The swivel type trucks as supplied on these standard locomotives meet these requirements by being built with sturdy cast steel bolster rigidly secured to the truck frames of rolled steel with ream-fitted bolts. This truck is illustrated in Fig. 2. The locomotive weight is transmitted to the journals through long semi-elliptical springs equalized, insuring smooth riding qualities and thus reducing the effects on the locomotive and equipment from the severe jolts and vibrations which the locomotive must meet in service.

If it is desired, swing bolster type trucks designed for locomotive service may be supplied, but as this type is usually unnecessary for the service requirements of these locomotives the standardization does not include this type of truck except as a specialty. The articulated type of truck may be supplied where especially required. However, as it is undesirable to burden store rooms with any more than absolutely essential material, the swivel truck is supplied as standard except where extreme conditions require some other type.

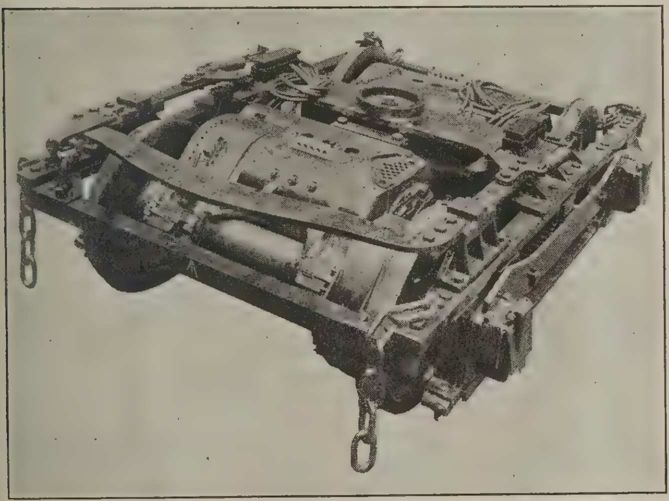


Fig. 2.—View of Standard Locomotive Truck

Special attention has been given to the design of the center-pins to enable them to easily withstand the buffing strains and transmit the tractive effort to the draw-bar. The location of center-pin being especially low, the tendency to transfer weight from one axle to the other when pulling or pushing heavy loads is considerably reduced.

The driving axles are of forged steel and meet the A. E. R. A. standard for diameter and bearing areas and conform to the M. C. B. journal sizes.

Either rolled-steel wheels or steel-tired wheels with cast-iron or cast-steel spoked centers are provided as standard having M. C. B. or A. E. R. A. tread and flange as required.

The cab underframing consists of center and side sills of standard rolled-channel section. The end frames being of all metal parts with no wood used in their construction reduces the danger of the locomotive being put out of service in the event of a collision. The end-sill design depends largely upon the type of couplers and draw-bar to be used and with the weight of locomotive desired. Radial draw-bar or a friction draft-gear can be supplied if required. Rolled-steel plates are riveted to the underframing to form the cab floor. These floors are made the full width and length of the cab. Rolled-steel plate cross-ties over the trucks are connected to the floor plates and sill by means of flanged plates, thus forming a strong girder of the box type for supporting each truck center-pin. One great advantage of the Baldwin-Westinghouse type of locomotive frame construction is that the frame is built almost entirely of commercial shapes, making a strong structure.

The locomotive cabs are of steel and of the so-called steeple type construction, consisting of a central box-shaped cab over the longitudinal center of the locomotive, with sloping hoods over each end of locomotive. There are three windows on each side and the ones nearest the operators' stations are arranged to slide as well as to drop. In each end of the cab are two windows, one stationary and the other arranged to drop. The window directly in front of the operator gives an unobstructed view of the track. A door is placed in each end of the cab, providing a ready means for entrance and exit.

The hoods at the end of the cab are of steel plate riveted to angle iron supports. Each hood has three doors, one on each side and one opening into the cab. The hoods contain the air compressors, blower motors and other apparatus which cannot conveniently be located in the central compartment of the cab. The hoods are built to shed water and are provided with a ventilator to prevent undue heating of the apparatus. The headlights and locomotive bell are usually located upon the hoods.

Multiple Unit Operation

At times roadbed, rail weight or structure on the right-of-way limit the maximum axle loading so that more than four axles are required to obtain sufficient locomotive capacity.

In such cases two or more locomotive units can be arranged to be connected in multiple and operated in tandem, the control of both units being possible from any control station on any unit.

Acknowledgment

There was published in the *Railway Electrical Engineer* for August an article entitled "The Manufacture of Rubber Insulated Wire." Through an oversight this article appeared without mentioning the names of the companies who furnished the basic facts. We take this opportunity, therefore, to acknowledge our indebtedness to the Okonite Company for the greater part of the information supplied for the preparation of the article, including the four photographs which were taken at this company's plant at Passaic, N. J.

Certain other portions of the article were abstracted from a booklet on the subject of "Rubber Insulated Wire," published by the Hazard Manufacturing Company of Wilkes Barre, Pa.

Principles of Car Lighting by Electricity

A Course of Practical Lessons Explaining the Main Details of This Important Application

By Chas. W. T. Stuart

III. Axle Generator System

THE third system of car lighting with axle driven generators was developed about the same time as the head end system, but was very unsatisfactory at first. It has been so much improved during recent years, however, that it has practically supplanted the turbo-generator equipment and is gradually pushing the straight storage system out of the field.

The axle generator system consists of a generator driven from the car axle, with a set of batteries and necessary regulating apparatus. When the car is in motion, the generator is automatically connected to the battery and lighting circuits, after which it furnishes current to charge the storage battery, and also to light the car. When the car is at rest, the generator is automatically disconnected from the battery and lighting circuits and the storage battery supplies the current for the lamps.

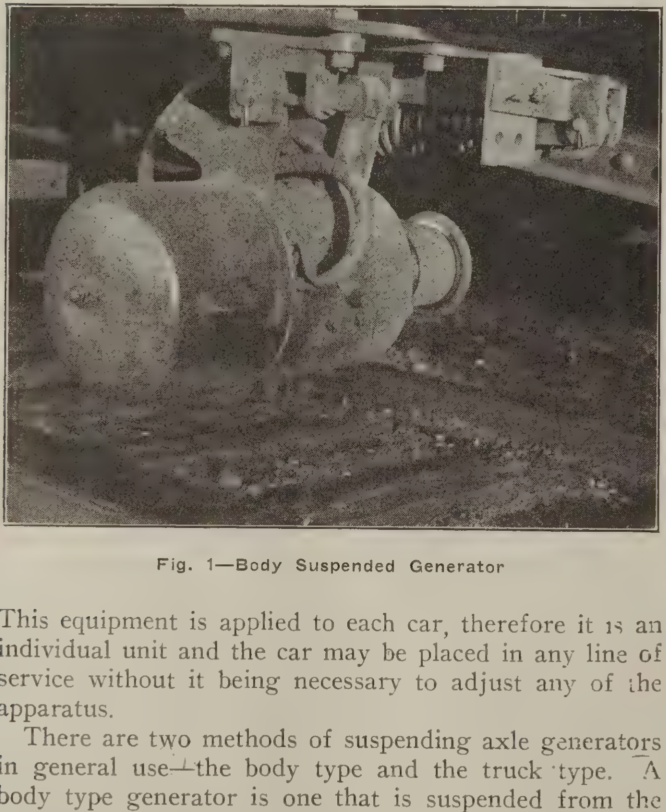


Fig. 1—Body Suspended Generator

This equipment is applied to each car, therefore it is an individual unit and the car may be placed in any line of service without it being necessary to adjust any of the apparatus.

There are two methods of suspending axle generators in general use—the body type and the truck type. A body type generator is one that is suspended from the car body, as shown in Fig. 1. A truck type generator is one that is suspended from the truck of the car, as shown in Fig. 2.

The axle generator is driven by a belt or chain from the car axle by the use of two pulleys, one, a large pulley, is bolted on the car axle and known as the axle pulley. The other, a much smaller pulley, is mounted on one end of the armature shaft and is known as the generator pulley.

Car Lighting Generators

All car lighting generators are direct current machines because direct current is required to charge a storage battery. These generators must also be water and dustproof, because they are suspended from under the car and operated in all kinds of weather. Because of this operating condition the circulation of air around the outside of the machine is depended upon to assist in keeping the generator at a safe operating temperature.

The speed and direction of rotation of the armature of an axle generator depends upon the speed and direction that the car is traveling, and as the car operates in either direction and at all rates of speed, perfect commutation is necessary over a wide range of speed in either direction. This is accomplished by setting the brushes for a full load for the average train speed, which gives good commutation at speeds below or above the average. The change in direction of rotation of the armature as the car is operated in either direction, gives rise to another problem and that is the question of polarity. When you discharge a storage battery the current will flow from the positive terminal of the battery to the lamps and return to the negative terminal of the battery, as shown in Fig. 3, and when charging a battery it is important that the charging current flows through the battery in the opposite direction to that of the discharging current, as shown in Fig. 4. Therefore when you connect a set of batteries to an axle generator the positive side of the generator must be connected to the positive side of the battery, and the negative side of the generator must be connected to the negative side of the battery.

Now that we know the correct polarity to be used in charging a battery, the question arises as to the polarity of the generator when the direction of the armature rotation changes, and although it is not intended to enter into elementary electricity in these lessons, it might be well to include briefly the relation between the direction of rotation of the armature to the polarity of a shunt wound direct current generator before describing the operation of the pole changers used in direct current shunt wound axle generators.

Direction of Rotation

If, when facing the commutator end of the armature of a dynamo, the rotation is in the direction of the hands of the clock, it is said to be *clockwise,* while the reverse direction is called *counter-clockwise.* If it is desired to reverse the direction of rotation of the same dynamo the connections between field and armature must be changed so that the current will flow through the field as before, otherwise the machine will not pick up. Fig. 5 shows the connection of a shunt wound machine for a clockwise rotation. Fig. 6 shows the same machine arranged for counter clockwise rotation with reverse polarity of the line wires; and Fig. 7 shows the connections for the counter-clockwise rotation retaining the same polarity of line wires as in Fig. 5. In both Figs. 5 and 6 the direction of the current through the field remains unchanged so that there is no disagreement between the direction of the field magnetism and that of the residual magnetism.

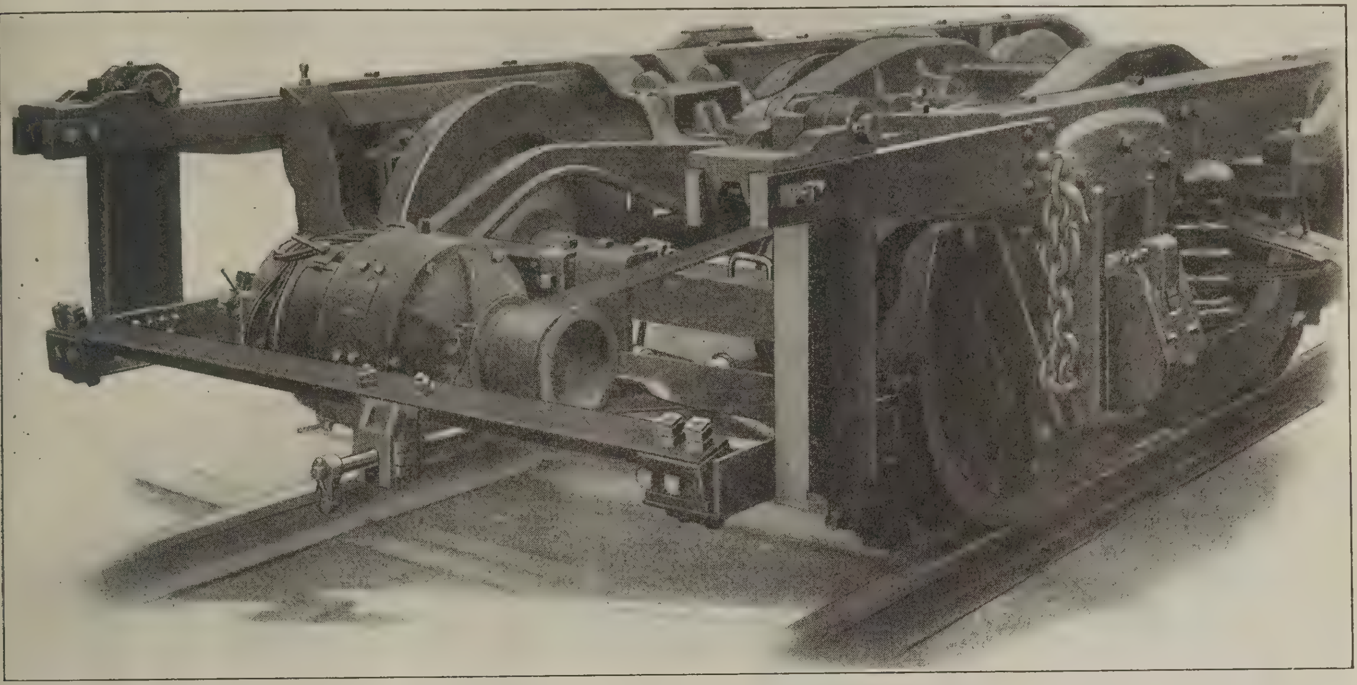


Fig. 2—One Method of Mounting the Generator on the Truck

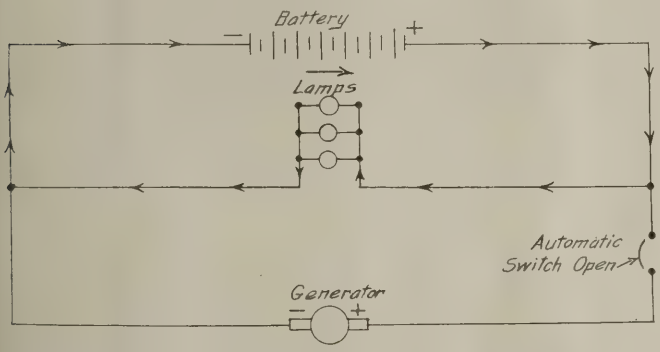


Fig. 3—Car Not in Motion—Automatic Switch Open—Lights Burning—The Current Flows From the Battery as Shown Above By Arrows

Shunt wound axle generators are equipped with a pole changer which keeps the polarity of the external generator leads constant regardless of the direction of armature rotation.

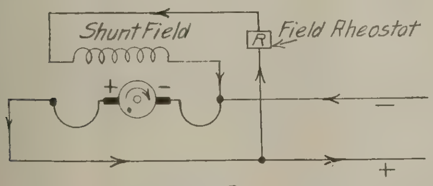


Fig. 5

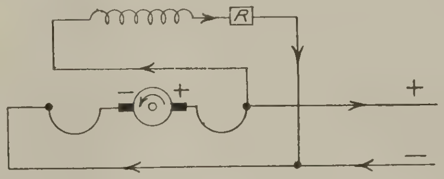


Fig. 6

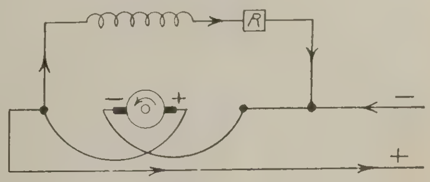


Fig. 7

Figs. 5, 6 and 7—Showing the Direction of Current Flow in the External Circuit With Relation to the Direction of Armature Rotation

The parts of a shunt wound direct current generator used for car lighting are the magnet frame, housing heads, poles, field coils and retainers, armature, brushes and brush holders, and pole changer. Fig. 8 is a sectional view of an axle generator showing the various parts.

Magnet Frame. The magnet frame is a one piece steel casting which houses the armature, field coils, pole pieces, and also carries the housing heads. The magnet frame is provided with hand holes at the commutator end for inspection purposes. These holes have water and dust-proof covers.

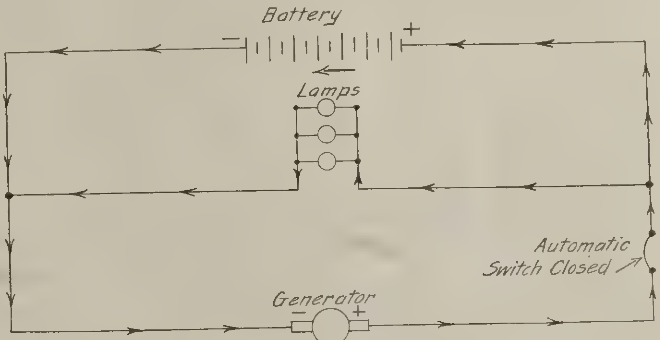


Fig. 4—Car in Motion—Automatic Switch Closed—Lights Burning—The Current Flows From the Generator to Battery and Lamps as Indicated by Arrows. Note that the Charging Current Passes Through Battery in Opposite Direction to That of Discharge Current as Shown in Fig. 3

Housing Heads.—The housing heads carry the ball bearings and are bolted to the magnet frame at each end.

Poles—The poles are the laminated type bolted to the magnet frame.

Field Coils and Retainers.—The field coils are held in position by the pole pieces and by field coil retainers which are either made of brass and bolted to the magnet frame or of wood and wedged between the pole pieces. The retainers make it impossible for the field coils to slip or wear by rubbing against the pole pieces.

Armature.—The armature is form wound. The coils are held in the core slots by hard fiber or wooden wedges and band wires. The armature core is built up of transformer iron laminations. Air spaces are provided in the core to secure cool running. The commutator bars are of hard drawn copper and insulated by a good grade of mica.

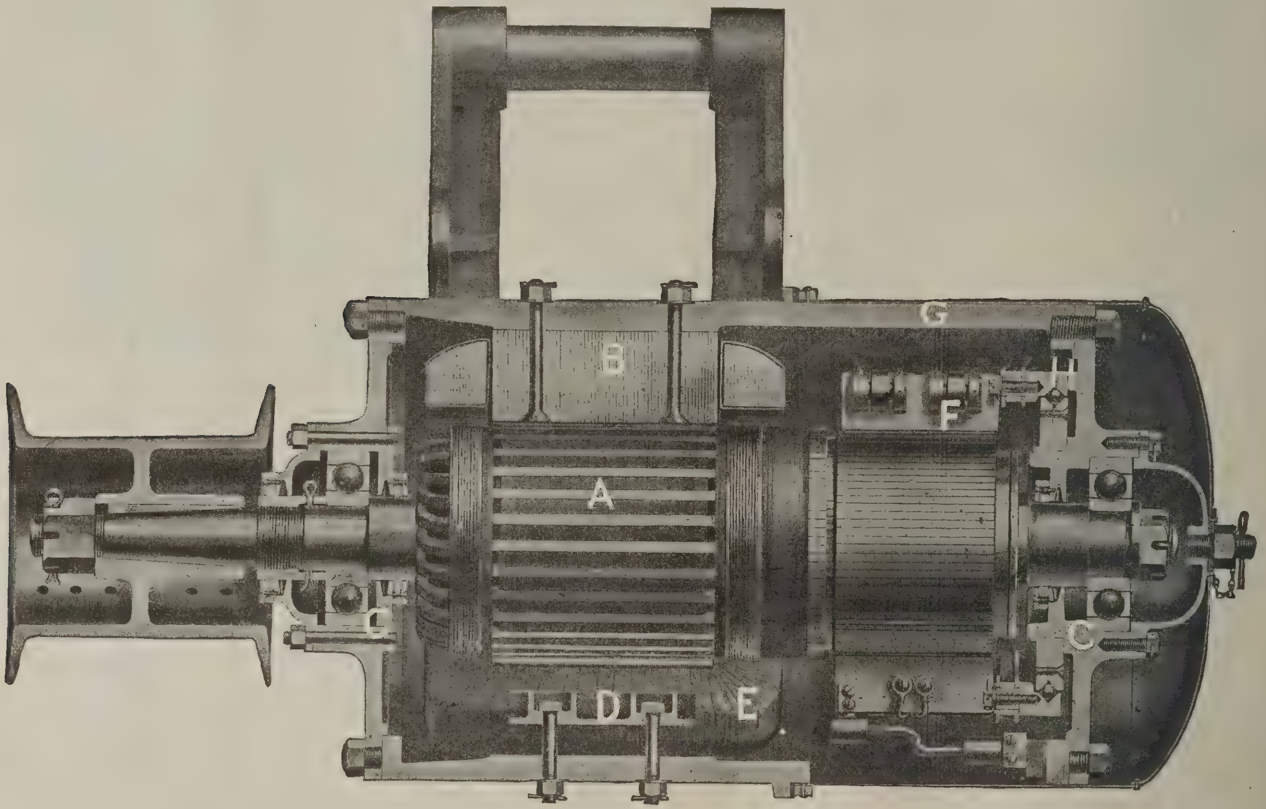


Fig. 8—Sectional View of an Axle Generator Showing the Various Parts. A—Armature; B—Pole; C—Housing Heads; D—Field Retainer; E—Field Coil; F—Brushes and Brush-Holders; G—Magnet Frames; H—Pole Changer

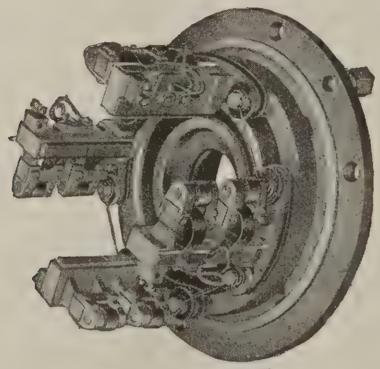


Fig. 9—Rotating Type of Pole Changer Mounted on Housing Head

Brushes and Brush Holders.—The brushes are of carbon which will not cut or gum the commutator. They are provided with flexible copper pig tails to give positive contact with the brush boxes. Each brush is provided with a separate spring of such design that the pressure on the brush is constant until the brush reaches its limit of wear. The brush boxes are brass or aluminum cast and are four in number.

Pole Changer.—There are two types of pole changers in general use today—the *rotating* type and the *mechanical* operated switch type.

The rotating type pole changer, Fig. 9, rotates the generator brushes through an angle of 90 degrees whenever the direction of armature rotation is changed. The four brush boxes are mounted on, but insulated from, a brush rocker which forms the outer race of a ball bearing and which is free to move through an arc of approximately 90 degrees. The friction between the brushes and the commutator is easily sufficient to rotate the pole changer or brush rocker when the direction of armature rotation

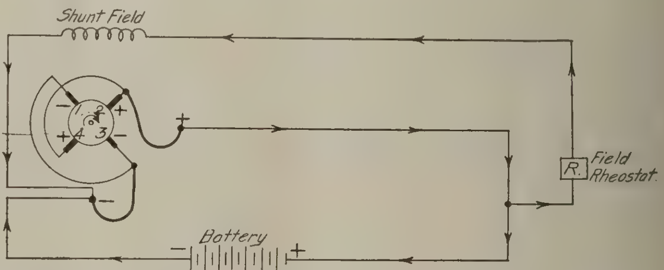


Fig. 10—Armature Rotating in Clockwise Direction. Battery Receiving Current With Correct Polarity

changes and the length of the arc of travel is determined by suitable stops on the pole changer rocker and on the housing head, these stops being so located that for either direction of car movement the brushes are placed in the proper position to secure good commutation. The principle involved in this type of pole changer is as follows: Starting with a car operating so that the armature rotates clockwise and the field and generator current flowing in a direction as shown by arrows in Fig. 10, the battery is receiving the charging current with the correct polarity. Before reversing the direction of rotation, note that the two positive brushes are placed at points 1 and 3 on the commutator and the two negative brushes at points 2 and 4. Next assume that the same car is operated in the opposite direction as shown in Fig. 11. The moment that the armature reverses its direction of rotation, the friction of the brushes on the commutator carries the brushes through an arc of 90 degrees against a stop, placing the positive brushes as shown in Fig. 11 at points 2 and 4, instead of 1 and 3, on the commutator and placing the negative brushes as shown at points 1 and 3 instead of 2 and 4. The field current and the generator current to the battery flow in the same direction as in Fig. 10, which shows the armature rotating in the opposite direction.

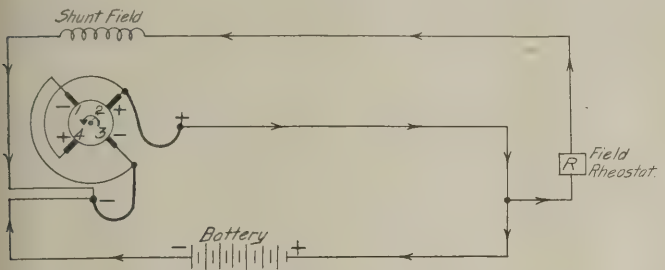


Fig. 11—Armature Rotating in Counter-clockwise Direction. Position of Brushes Has Shifted But Direction of Current in External Circuits is the Same as in Fig. 10

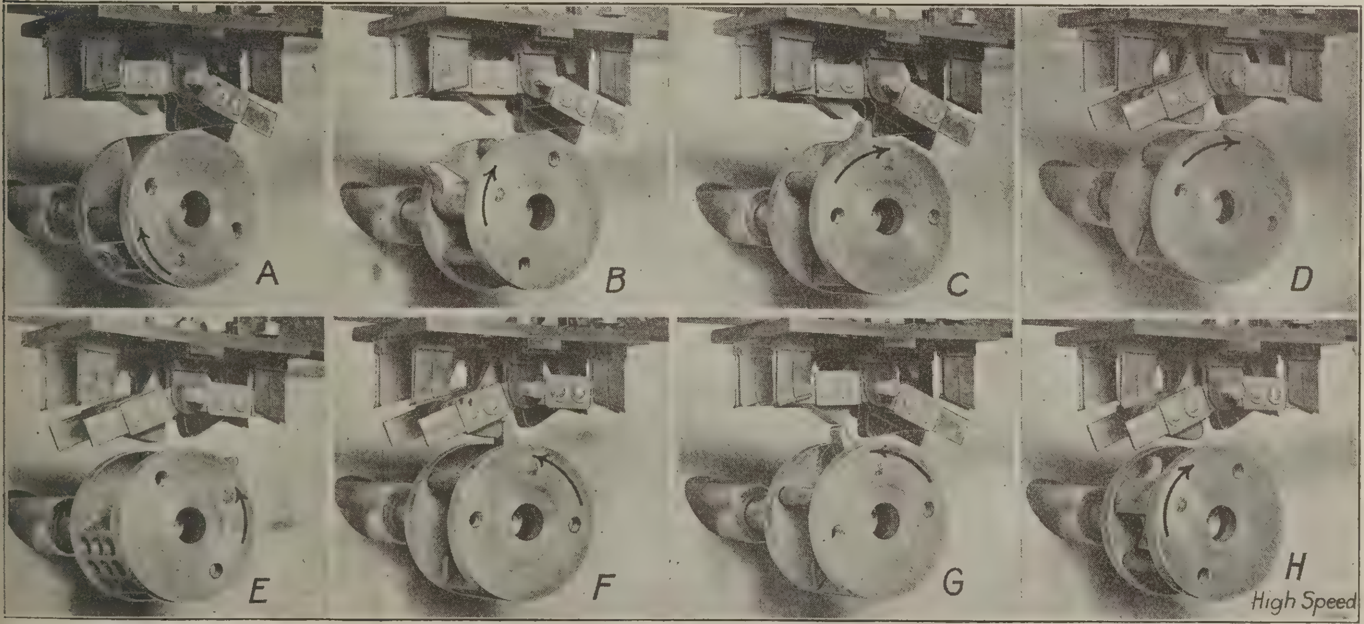


Fig. 12a—Successive Views of the Pole Changer Shown in Fig. 12. This Series of Photographs Shows How the Pole Changing Switch Is Thrown by the Rotating Trip According to the Direction in Which the Armature is Rotating

The mechanically operated switch type pole changer, Figs. 12 and 12a, consists of a double-pole double-throw knife switch connected between the brush leads and the external leads of the generator and a trip which is arranged in a carrier and mounted on the armature shaft.

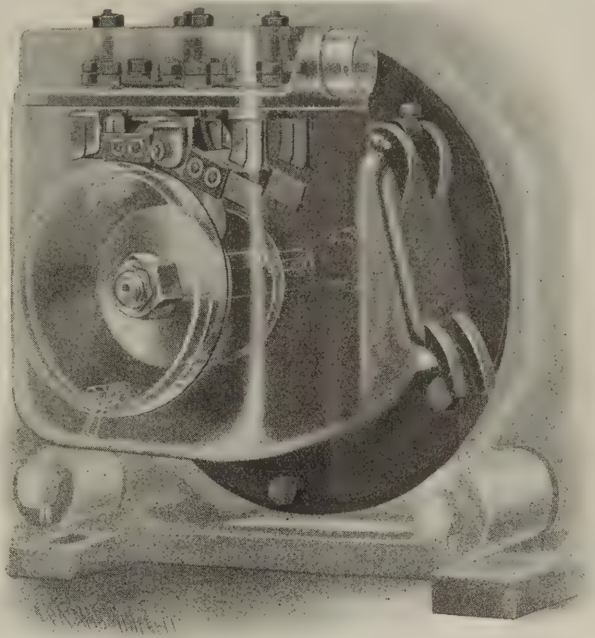


Fig. 12—Phantom View of Mechanically Operated Switch Type Pole Changer

The trip has two projections which engage corresponding lugs which are connected to, but insulated from, the front and rear blade of the switch. As soon as the switch is tripped, its throw is completed by a spring toggle which also holds the switch in place. The principle involved in this type of pole changer is as follows: Starting with the car operating so that the armature rotates clockwise, the two-pole double-throw switch thrown to the right side and the field and generator current flowing in a direction as shown by the arrows in Fig. 13, the battery is receiving the charging current with the correct polarity. Next assume that the same car is operated in the opposite direction. This means that the armature will rotate in the opposite direction or counter-clockwise. As the armature turns over in the opposite direction the two-pole double-throw switch is tripped to the left side and when the generator builds up the current will flow through the field and to the battery as shown by arrows in Fig. 14.

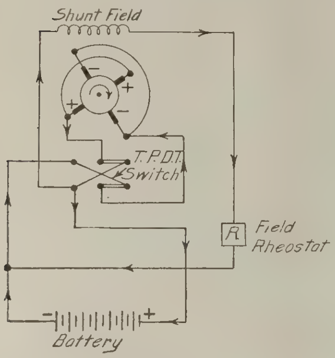


Fig. 13

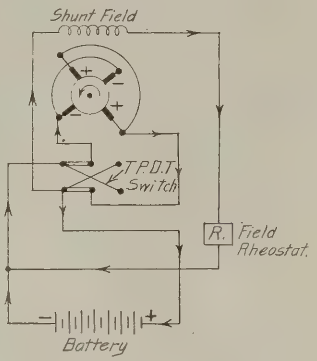


Fig. 14

Fig. 13—Clockwise Rotation and Switch Tripped to Right Side
Fig. 14—Counter-clockwise Rotation and Switch Tripped to Left Side

Note that in Fig. 13 and Fig. 14 the field and battery current flow in the same direction but that the polarity of the generator leads between the armature and pole changing switch reverses with the direction of rotation. There is one axle generator in use today that requires no pole changer, known as the E. S. B. generator. The electrical characteristic of this generator is such that the same polarity prevails regardless of the rotation of the armature. This equipment will be described in a future lesson.

Association of Railway Electrical Engineers to Amend Constitution

A number of amendments to the present constitution of the Association of Railway Electrical Engineers have been submitted to the secretary of the association by five senior active members. These proposed amendments are submitted with a view of providing a more satisfactory method for the election of officers and members of the executive committee and also to eliminate certain features of the constitution that are obsolete. Under the proposed amendments, officers and members of the executive committee, with the exception of the secretary-treasurer and members of the committee on nomination, will be elected by letter ballot, thus permitting all active members qualified to vote to do so, instead of only those who are able to attend the last session of the annual convention. Provision is also made to amend the constitution by letter ballot. The amendments, which have been drawn up to harmonize with the proposed amalgamation with the American Railroad Association, are presented here in full:

Article V, and Sections 1, 2 and 3 now reading:

ARTICLE V.

Officers.

Section 1. The officers of this Association shall be a President, two Vice-Presidents, a Secretary-Treasurer, and six Executive members, who, together with the officers, shall constitute the Executive Committee. The members of the Executive Committee will hold office for a period of three years, two members to be elected at each annual meeting.

Section 2. The officers of the Association, with the exception of the Secretary-Treasurer, shall be elected from the Senior Active members by separate ballot, without nomination, at each annual meeting. Two tellers shall be appointed by the President to conduct the election and report the result. A majority of all votes cast shall be necessary to elect. The election must proceed without adjournment or interruption of other business.

Section 3. The terms of each officer, except the Secretary-Treasurer, shall begin at the close of the election and shall continue for one year or until their successors shall be elected and qualified. One Vice-President shall be elected from the Eastern Section, and the other Vice-President from the Western Section as hereinafter defined.

The Secretary-Treasurer shall be appointed by a majority vote of the Executive Committee and shall be continued in office until his office shall become vacant as prescribed in Section 6 of Article Five.

There must be at least one member of the Executive Committee elected from each of the Eastern and Western sections.

To be amended to read:

ARTICLE V.

Officers and Executive Committee.

Section 1. The Executive Committee of the Association shall consist of ten members including the officers of the Association who shall be a President, two Vice-Presidents and a Secretary-Treasurer.

Section 2. The term of office of each officer, except the Secretary-Treasurer, shall begin at the close of the annual meeting and shall continue for one year or until their successors shall be elected and qualified. One Vice-President shall be elected from the Eastern Section and the other Vice-President from the Western Section as defined in Section 5 of Article V.

The Secretary-Treasurer shall be appointed by a majority vote of the Executive Committee and shall continue in office until his office shall become vacant as prescribed in Section 7 of Article V.

The terms of the six other members of the Executive Committee shall begin at the time of their election and shall continue for a period of three years. Two of the members shall be elected each year, one of these to be from the Eastern Section and the other from the Western Section as defined in Section 5 of Article V.

Section 3. The officers of the Association, members of the Executive Committee and members of the committee on Nominations, with the exception of the Secretary-Treasurer, shall be elected from the Senior Active members by written or printed ballots provided for the purpose. The candidate for each office receiving the greatest number of votes shall be declared elected. The Executive Committee shall have ballots prepared as prescribed in Section 4 of Article V, which shall be mailed by the Secretary-Treasurer at least thirty days prior to the annual meeting, to all Senior Active members, who, after recording their vote will return them to the Secretary-Treasurer. Votes will be received until noon of the day preceding the opening day of the annual meeting, when all votes received shall be placed in a sealed package and kept by the Secretary-Treasurer until the session at which the results of the election are announced.

Section 4. In ballots for officers, members of the Executive Committee and Committee on Nominations the following form of voting shall be adhered to. Envelopes shall be provided on which there is a blank space for the name of the railroad, the name of the Senior Active member voting, and shall be marked "Official Voting Envelope"; small unmarked envelopes shall also be provided. One of each of these envelopes and a ballot will be sent to every Senior Active member. After marking the ballot it is to be placed in the smaller unmarked envelope and sealed, this in turn being placed in the "Official Voting Envelope." After entering the name of the railroad and of the Senior Active member voting in spaces provided for this purpose the envelope is to be returned to the Secretary-Treasurer. The ballots shall have placed on them the list of candidates for officers and members of the Executive Committee suggested by the Committee on Nominations, and blank spaces for other candidate members may desire to vote for. In addition, there shall also be placed *on the ballots the list of candidates for the new Committee on Nominations suggested by the Executive Committee and blank spaces for others. Members may vote either for the candidates listed or for any other Senior Active member for any of the offices by placing the name in the blank space provided for that purpose.*

The President shall appoint four tellers who shall have charge of the recording of the ballots cast, reporting the results of the election and shall be judges of the legality of any ballot presented. The results of the election shall be announced in that session of the annual meeting as arranged for in the order of business in Section 5 of Article IX.

When a ballot for officers or membership on the Executive Committee or Committee on Nominations shall be announced as having eventuated in a tie vote, or be otherwise undecided, announcement shall be made to that effect and the final result shall be determined by the majority of the votes of the members present.

Present Sections 4, 5 and 6 of Article V to be renumbered Sections 5, 6 and 7 respectively. Reference to "Section 3" in second line of present Section 4 to be changed to read "Section 2."

Article VI, Section 4, now reading:

Section 4. The Executive Committee shall manage the affairs of the Association and shall have full power to control and regulate all matters not otherwise provided for in the Constitution, except to make the Association liable for debt to an amount greater than that which, at the time of contracting the same, shall be in the Secretary-Treasurer's hands in cash and not subject to prior liabilities. It shall have the proceedings of the regular meetings of the Association published and, subject to the action of the Association, may withhold from the same, the whole or in part, papers, reports of its management as recorded in the minutes of its proceedings, when called upon by two-thirds vote of the Association.

To have the following added:

The Executive Committee shall prepare a list, to be placed on the ballot, of the names of ten Senior Active members, not officers or members of the Executive Committee, as candidates for the five members of the Committee on Nominations.

Add new section to Article VII to be designated as Section 1, reading as follows:

Section 1, Committee on Nominations: A Committee on Nominations consisting of five Senior Active members, not officers of the Association or members of the Executive Committee, shall be elected annually as prescribed in Section 4 of Article V. It shall be the duty of the Committee on Nominations to present to the Executive Committee not later than sixty days prior to the annual meeting the names of one Senior Active member as candidate for President, one for Vice-President from the Eastern Section, one for Vice-President from the Western Section, one for member of the Executive Committee from the Eastern Section, and one for member of the Executive Committee from the Western Section.

Article VII, Section 2, now reading:

Section 2. Committee on Subjects for investigation and Discussion: At each annual meeting the President shall appoint a Committee whose duty it shall be to report to the Executive Committee subjects for investigation and discussion. It shall also be the duty of this Committee to receive from members questions for discussion, and if such questions are deemed suitable, to report them to the Association at the regular meetings.

To be amended to read, and to be renumbered Section 3:

Section 3. Committee on Subjects: The President shall appoint a Committee on Subjects, consisting of five members of the Executive Committee, including the Secretary-Treasurer, whose duties it shall be to report at the next annual meeting subjects for investigation and discussion, and if the subjects are approved by the Association, the Executive Committee shall appoint committees to report on them. It shall also be the duty of the Committee on Subjects to receive from members questions for discussion, and shall determine whether such questions are suitable for discussion, and if so, shall report them to the Association at the regular meetings.

Present Sections 1, 3 and 4 to be renumbered 2, 4 and 5.

Article VIII, Section 2, now reading:

Section 2. On any question pertaining to standards, standard practice or specifications, etc., other than electric car lighting exclusively, the ranking Senior Active member of any railroad shall be entitled to one vote on each question.

To have the words "other than electric car lighting exclusively" struck out.

Article VIII, Sections 3 and 4, now reading as follows to be eliminated.

Section 3. The number of electrically lighted cars which the Senior Active members will be entitled to vote upon will be the number of such cars owned on June 1st in any one year, and all questions coming up for letter-ballot of the succeeding year, the vote will be on number of electrically lighted cars as on June 1st for the year running from June 1st to May 31st.

Section 4. On any question pertaining entirely to electric car lighting the ranking Senior Active member of any road will vote the electrically lighted cars owned by the road which he represents, as follows: One vote per car.

Article VIII, Section 5 to be renumbered Section 3.

Article IX, Section 1, now reading:

Section 1. The regular annual meeting of the Association shall be held at the time and place selected by the Association at the previous annual meeting. One other regular meeting shall be held at time and place decided upon at each previous meeting.

The Executive Committee may, however, change the time and place for holding the regular meeting other than the annual meeting, and may at the written request of ten Senior Active members, in its discretion, call a special meeting at such time and place as may be designated in the request.

All regular business of the Association shall be transacted at any regular meeting of the Association.

To be amended to read:

The regular annual meeting and semi-annual meeting of the Association shall be held at the time and place selected by the Executive Committee.

The Executive Committee, may, at the written request of ten Senior Active members, in its discretion, call a special meeting at such time and place as may be designated in the request.

All regular business of the Association shall be transacted at any regular meeting of the Association.

Article IX, Section 2, now reading:

Section 2. The Executive Committee shall select and arrange for the necessary meeting rooms for the meeting of the Association, and shall recommend at each annual meeting for the choice of the Association, one or more places for holding of the next annual meeting.

Eliminate the following from the above section:

"And shall recommend at each annual meeting for the choice of the Association one or more places for holding of the next annual meeting."

Article IX, Section 5, now reading:

Section 5. The order of business at meetings of the Association shall be as follows:

1. Consideration of minutes of last meeting.
2. Address of the President.
3. Report of the Secretary-Treasurer.
4. Unfinished business.
5. New business.
6. Reports of Standing Committees.
7. Reports of Special Committees.
8. Miscellaneous business.
9. Selection of place for next annual and semi-annual meetings.
10. Election of officers.
11. Adjournment.

This order of business preceding the election of officers, may, however, be varied from on a majority vote of the Senior Active members present at the meeting.

To be changed as follows:

Item 9 to be struck out. Item 10 to be renumbered item 6 and to read:

6. Announcement of election of officers, members of Executive Committee and Committee on Nominations.

With exception of renumbering the items following new Item 6 no other changes will be made in this Section.

Article X, now reading:

Proposed amendments to the Constitution must be offered in writing, signed by not less than five Active members, and must be published in the advance copies of the Annual or Semi-Annual meeting. The amendments shall be acted upon at such

Annual or Semi-Annual meeting and shall be adopted if the votes of two-thirds of the Senior Active members voting are affirmative.

To be amended to read as follows:

Proposed amendments to the Constitution shall be presented to the Executive Committee in writing signed by not less than five Senior Active members. The proposed amendments shall be submitted to letter ballot not later than sixty days prior to the annual or semi-annual meetings, following the method of procedure corresponding to that prescribed in Section 4 of Article VI for election of officers, members of the Executive Committee and Committee on Nominations. The ballots shall be returned to the Secretary-Treasurer not later than noon of the day preceding the opening of the meeting, and the results of the vote shall be announced during the meeting. The amendments shall be declared adopted if two-thirds of the votes cast are affimative and providing fifty per cent or more of the Senior Active members in good standing shall have voted.

It is recommended that the proposed amendments be submitted to the Association in the manner as prescribed in the Constitution for formal action at the October meeting. If the amendments are adopted, it is desired to put them in effect for the election of officers for 1921-2. To accomplish this it is proposed that the first Committee on Nominations shall be elected as follows:

The Executive Committee shall submit at the 1920 annual meeting a list of the names of ten Senior Active members, not officers or members of the Executive Committee, as candidates for the Committee on Nominations. The members for the Committee shall be elected in the usual manner at the session at which the officers for 1920-1 are elected.

Submitted July 31, 1920, by the following Senior Active Members:

L. S. Billau,
C. H. Quinn,
F. J. Hill,
J. R. Sloan,
Louis D. Moore.

The Kleinschmidt Printing Telegraph

The Kleinschmidt Electric Company, New York City, is now putting on the market an improved form of its automatic printing telegraph apparatus, simplified in construction, capable of increased speed and fitted with various improvements. The illustration shows a typical set for transmitting and receiving where the wire is worked duplex.

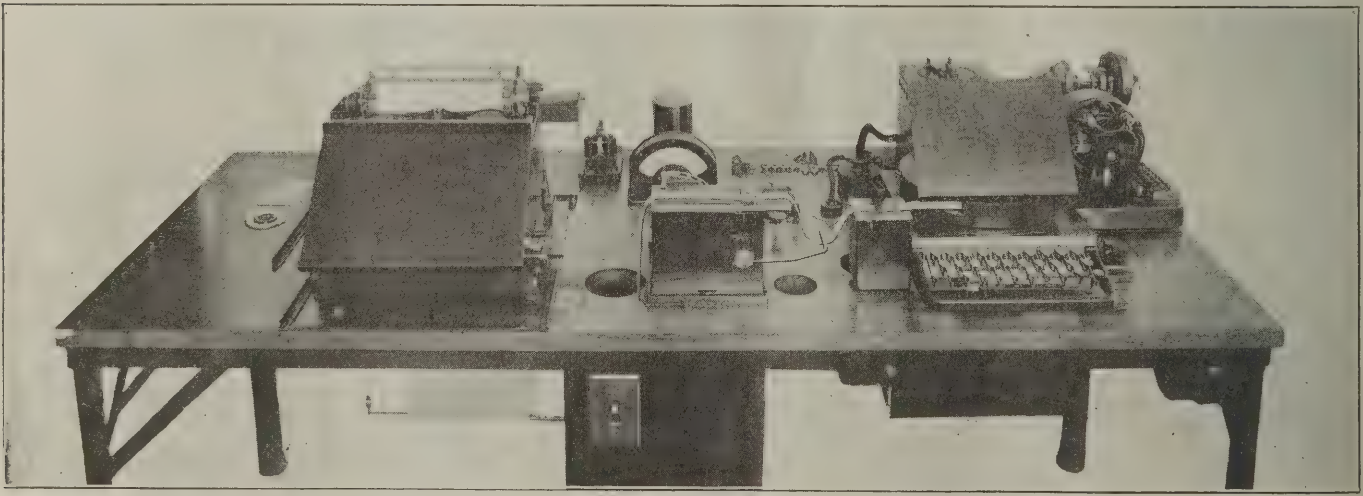
The message to be sent is prepared on a tape, as in other rapid telegraphs, the operator doing the perforating by means of keys on a standard typewriter keyboard, minus the lowercase letters. The Baudot multiplex code is used.

The automatic transmission of messages over the line is regulated, to correspond with the speed maintained by the operator, by means of an automatic switch. After the operator has perforated four or five inches of tape, the beginning of the message is inserted in the transmitter (in the middle of the table) and the switch lever (a light bent wire) then rests on the tape. Assuming that the operator works as fast as or faster than the transmission speed of the wire—60, 70 or 80 words a minute—there is an accumulation of slack in the tape and the lever remains in its lowest position, as shown in the illustration. The transmitter now functions. If the operator completes the messages on hand, or operates at a lower speed than the impulses are sent out over the line, then the tape tends to become taut; and this lifts the lever and thereby cuts out the transmitter from its circuit. Later, when a new supply of tape has been prepared, that part of it between the machines again becomes slack; and by the movement of the lever downward the transmitter is once more started.

The transmitter sends negative and positive impulses through the distributor to the line. These are received at the receiving end by a polar relay and the distributor there controls the local receiving circuit. With duplex working the printer needs but little attention, and the transmitting operator has time to act as receiving operator, tearing off the incoming messages as they are completed.

A Morse key and sounder are provided for use in balancing the duplex, but the bell signals on the printer can also be used for signaling from station to station whenever it is desired to do so.

This apparatus is sold direct to users. In tests carried out for a period of four months these printers have worked continuously to the extent of turning out 56,000 words without errors. Hindrances from operating difficulties were practically negligible. The apparatus works at a lower line frequency per letter than other printing telegraphs and there is, therefore, less liability to interruptions.



The Kleinschmidt Printing Telegraph

Starters and Controllers for A. C. Motors

Pointing Out the Importance of Protective Features Used in the Various Equipments

By Gordon Fox

THE principles underlying the action of alternating current motors and controllers have been previously outlined. The control requirements differ according to motor size and type. The equipments available will therefore be considered as applying for single-phase motors and for polyphase induction motors of the squirrel cage and wound rotor types respectively.

Single-phase induction motors are commonly built in sizes from 1 hp. to 15 hp. They do not ordinarily include a split-phase winding such as is employed to render fractional horsepower induction motors self-starting. More commonly, a polyphase stator winding is supplied, and an external split-phasing device employed to supply out-of-phase currents for starting. The principles of action and the connections for this scheme have been previously set forth. Fig. 1 illustrates a face plate type of starter for single-phase induction motors working on this principle. In appearance, this starter is quite similar to the ordinary direct current face plate starter.

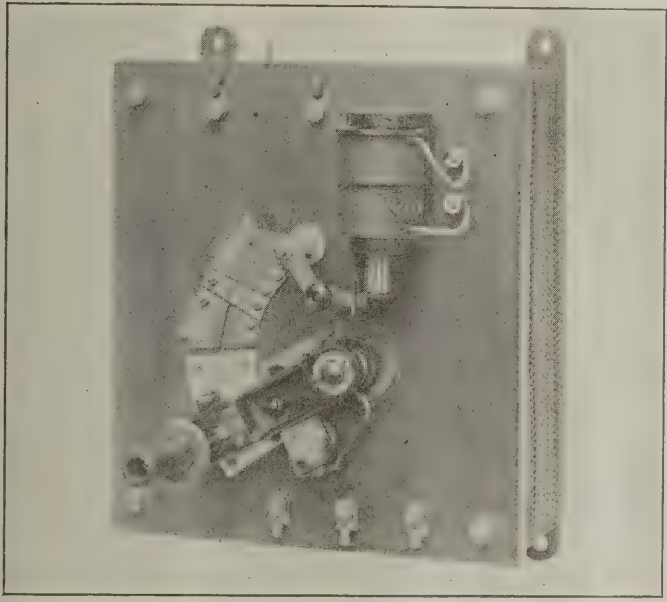


Fig. 1—Split-Phase Starter for Single-Phase Induction Motor

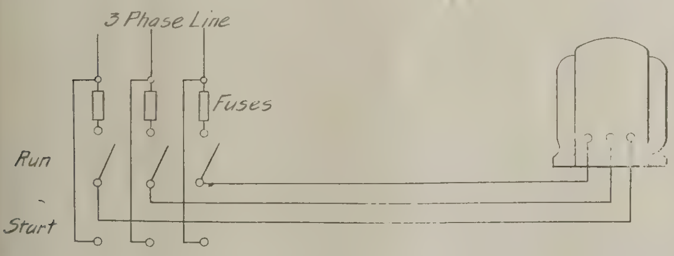


Fig. 2—Double Throw Knife Switch Starter for Small Squirrel Cage Induction Motor

Single-phase motors of the repulsion types are more commonly started by connection direct to the line through a knife switch or circuit breaker. For the larger sizes, accelerating resistance may be supplied to reduce the current peaks. A starter for this purpose resembles quite closely the direct current face plate type hand starter.

The smaller polyphase induction motors are nearly all of the squirrel cage type. Squirrel cage motors of 2 hp. and 3 hp. sizes are sometimes started by a multi-pole fused knife switch, connecting them directly across the line. This method is simple and inexpensive, but leaves much to be desired in safety and protective features. Motors of 5 hp. and 7½ hp. sizes are sometimes provided with a multi-pole, double-throw knife switch, one side fused, as shown in Fig. 2. The switch is first closed on the unfused side and then on the fused side. This is done to by-pass the fuses during the starting operation so that they may be light enough to protect the motor from overloads. This method also leaves much to be desired. If the operator throws to the running side too quickly he will likely blow his fuses. He is then tempted to replace them with larger fuses and destroy his protection. Not infrequently the fuse in one phase blows, leaving the other fuses intact. The motor continues to run single phase and overheats. Many a motor has been burned out in this manner. In case of a power interruption the switch remains in the running position unless opened by the operator. Upon return of power the fuses are then quite sure to blow.

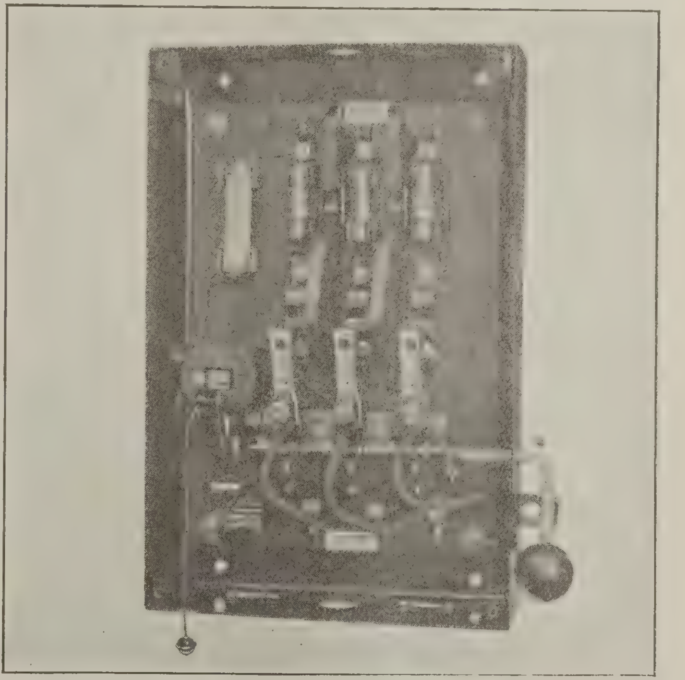


Fig. 3—Combination Starting Switch for Small Polyphase Induction Motor

To overcome the shortcomings of ordinary knife switch starters, a number of devices have been used. A safety switch type, with cover removed, is shown in Fig. 3. The mechanism is enclosed in a cabinet, an external handle being provided. Fuses are depended upon for overload protection. To by-pass the fuses during the starting interval an ingenious mechanism is employed, causing the switch to close first on the by-pass contacts and then on the fused contacts. A no-voltage trip feature is included. The connection scheme is illustrated in Fig. 4.

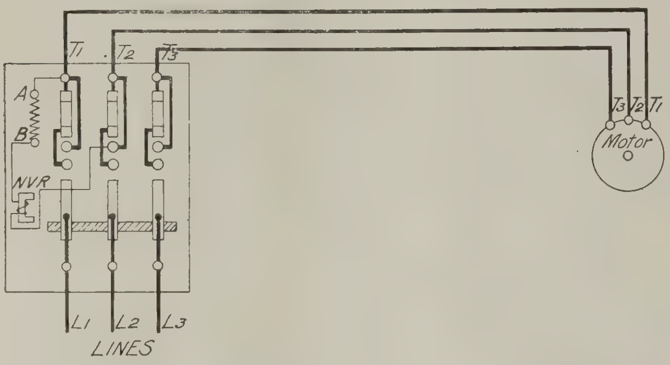


Fig. 4—Diagram of Switch Type Starter for Small Polyphase Induction Motor

Circuit breakers have a number of features adapting them for use in starting small multi-phase squirrel cage motors. They may be equipped with overload coils in two of the phase leads so that an overload on any phase will open the breaker and disconnect all phases from the line. This prevents single-phase running. The overload protection may be arranged with time element feature to prevent opening of the breaker during the starting interval. Circuit breakers may also be equipped with undervoltage trip coils so that the breaker will trip upon failure of power, affording "no-voltage protection." This feature may be employed in connection with push buttons to trip the breaker and stop the machine from remote points. Circuit breakers to be used for this service should generally be enclosed and externally operated. Even then they may lack the ruggedness required for many industrial applications.

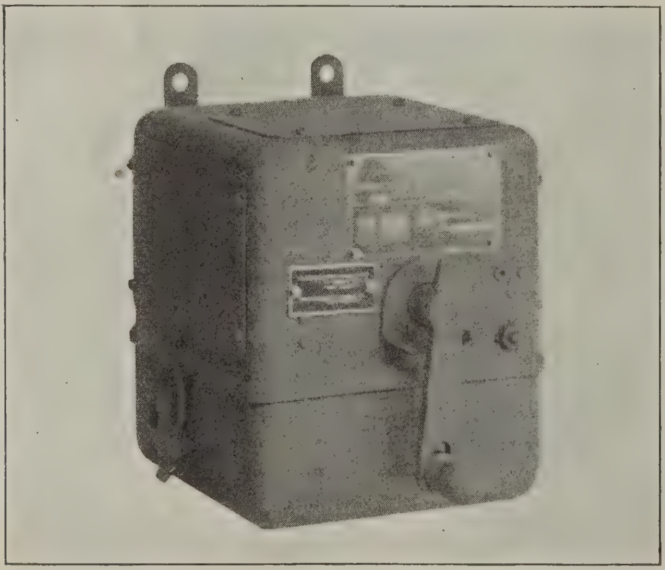


Fig. 5—Oil Switch Type of "Across the Line" Starter for Small Squirrel Cage Induction Motor

Oil circuit breakers have been developed in small sizes for starting small polyphase motors. Fig. 5 illustrates a device of this type. The mechanism is entirely enclosed, the contacts being submerged in oil. A no-voltage protection feature is included and two overload relays are provided to protect the motor. These relays are of the inverse time element type so that ordinary starting currents will not trip the switch. The trip mechanism is operative independent of the handle so that the protective features cannot be defeated by blocking or tying the handle.

It is standard practice to start squirrel cage motors, in sizes to 5 hp. inclusive, by connecting to full line voltage with some type of starting switch. This practice is also permissible for larger motors providing the starting duty is light, the driven machine capable of sustaining the shock and the high current peaks not objectionable. It is advisable, however, not to exceed a limit of 15 hp. except as an emergency measure.

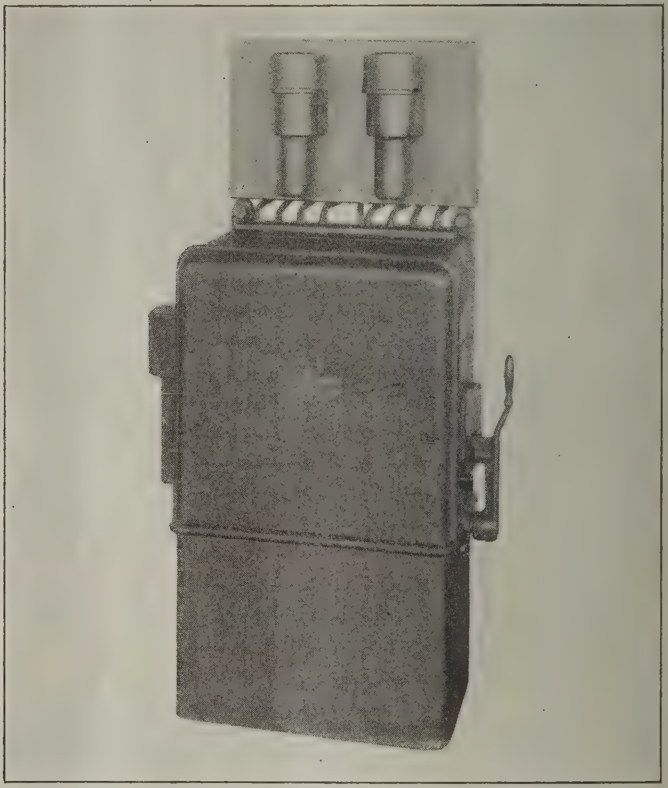


Fig. 6—Starting Compensator for Polyphase Squirrel Cage Induction Motor

The majority of squirrel cage motors are started by connecting them to a reduced primary voltage during the starting interval. This voltage may be obtained by the use of primary resistance or by transformer methods previously outlined in principle. The primary resistance method is not commonly employed for direct manual starters.

Starters for squirrel cage induction motors operating upon the transformer principle are commonly termed "auto-starters" or starting "compensators." They comprise three essential elements, namely: transformers to provide reduced voltage; switching means to connect motor first to reduced voltage, then to full voltage; protective features. A common type of auto-starter is illustrated in Fig. 6. A core-type three-phase air-cooled transformer is provided, equipped with several taps in each phase for selection of starting voltage. The transformer is wye connected. The switching arrangement comprises a rocker shaft with contact fingers and flexible leads. This portion of the outfit is submerged in oil. In order to prevent throwing the motor directly across the line an interlock is provided, acting on the rocker switch to make it necessary that the handle be thrown to starting position before it may be thrown to running position. A no-voltage trip feature is regularly provided. Overload protection may be secured, either by use of fuses or by means of relays acting upon the no-voltage trip. These fuses or relays are by-passed during the starting interval. Connection diagrams for two auto-starters were shown in previous discussion.

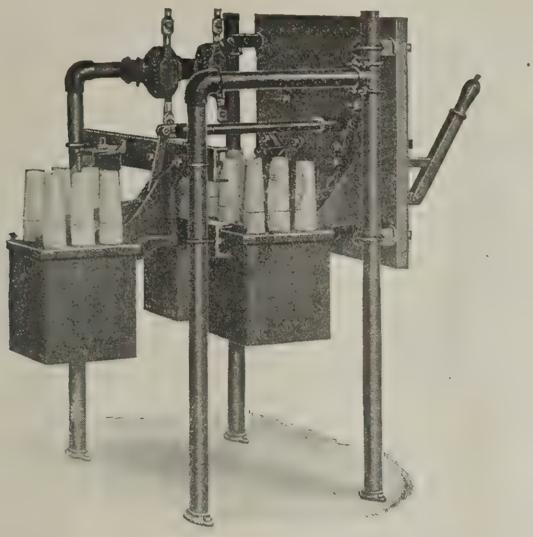


Fig. 7—Oil Switch Auto-Starter of the 3-Unit Type

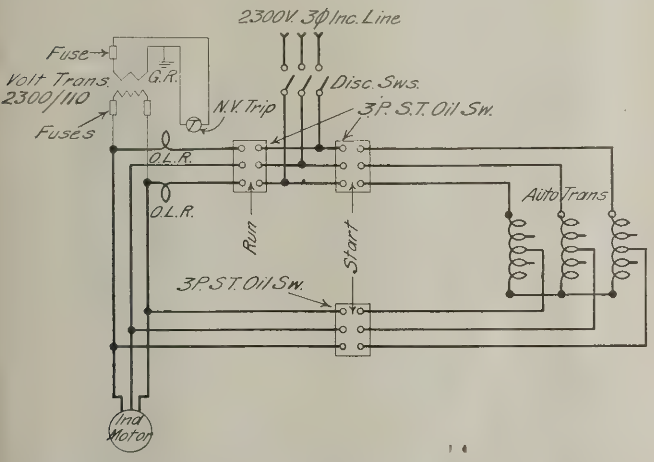


Fig. 8—Diagram of Oil Switch Type Auto-Starter for Squirrel Cage Induction Motor of Large Size or High Voltage

Small auto-starters are equipped with self-contained transformers. In the larger sizes it is more common to provide oil switches working in connection with separate transformers. The transformers may be either air-cooled or oil-cooled, the former being more common. In some cases the auto-transformers may be omitted altogether, the reduced starting voltage being taken from taps of the power transformers feeding the motor. Protective features, as required, are provided to act upon the oil switch.

Fig. 7 illustrates an equipment utilizing three separate oil switches for magnetizing, starting and running circuits, these switches being operated double-throw by two handles. Fig. 8 shows the connection diagram. Fig. 9 is the diagram of a similar equipment using two separate oil switches. Fig. 10 is the diagram of a large double-throw single-unit oil switch employed for the same purpose.

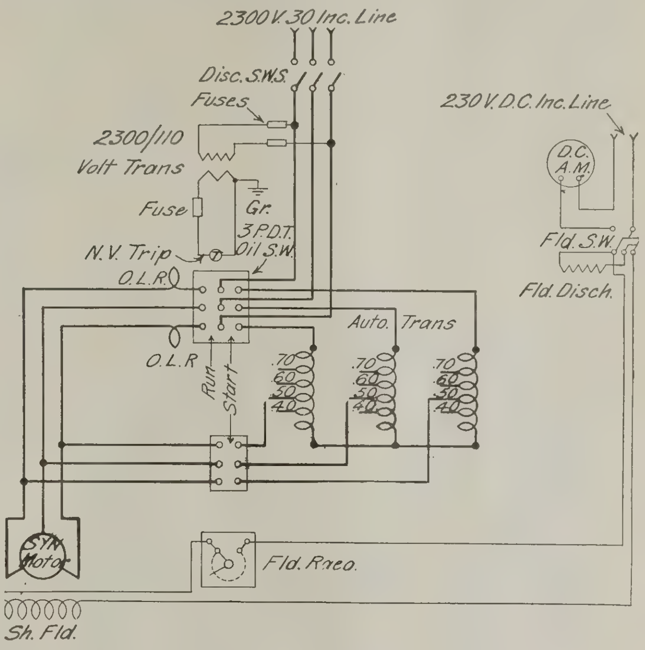


Fig. 9—Oil Switch Type Auto-Starter for Synchronous Motor Starting As An Induction Motor

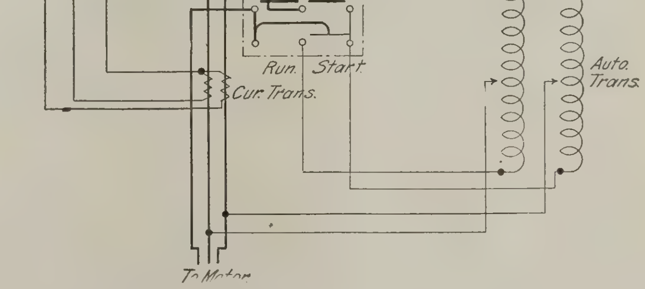


Fig. 10—Diagram of Oil Switch Type Auto-Starter for High Voltage Squirrel Cage Induction Motor

The manually operated auto-starter has limitations which, in some cases, may prove to be serious drawbacks. The operator must be trusted to afford the proper time interval for acceleration with the handle in the starting position. In case the fuses blow or the overloads trip the operator may tie or block the starting handle in the starting position. Like all manual devices, it is subject to abuse. It must be located convenient to the operator. Being comparatively bulky, it may prove an obstruction or may be exposed to damage. Being of a direct manual type, it requires that wiring for the full motor current be run to it and from it. To overcome some of these disadvantages, so-called "automatic compensators" have been developed. These are similar in principle to the annual types but are magnet-operated.

One device of this type is illustrated in Fig. 11. This device includes a two-coil, open-delta connected auto-transformer mounted in the lower part of a frame. Above this is mounted a solenoid with its armature connected to a toggle mechanism, for making the connections. A transition relay, working on the current limit principle, is located at the left. This serves to transfer a rocker switch, bearing the contact fingers, from the starting position, on the transformer, to the running position, on the line. The entire frame and mechanism is enclosed and submerged in a tank of oil. Control is by push button or automatic contacting device. Protection is afforded by a protective panel connected ahead of the compensator. The connections of the entire equipment are shown in Fig. 12.

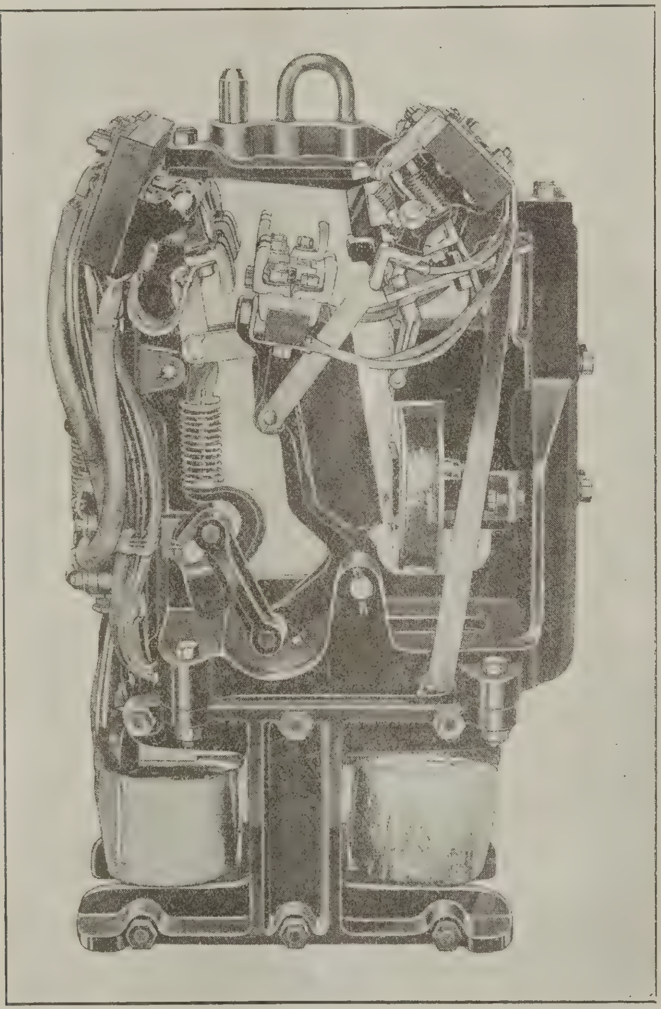


Fig. 11—Automatic Compensator for Squirrel Cage Induction Motor

Another "automatic compensator" is shown, partially exposed, in Fig. 13. The connections are shown in Fig. 14. This device resembles closely the manual autostarter or compensator except that it is magnet-operated. This equipment operates on the time element principle. The control station embraces a spring and clock mechanism operated by a small lever the counterpart of the familiar telegraph call box. When the starting lever is depressed a contact is made in the control station, causing the magnets in the compensator to close the throw-over switch in the starting position. After a definite time the control station automatically causes this contact to open and makes another contact which causes the magnets in the compensator to transfer the throwover switch to the running position. The time element is introduced by the clock mechanism in the control station and is adjustable. When desired an "inching" feature may be included. The advantage of the time element principle as compared with the current limit prin-

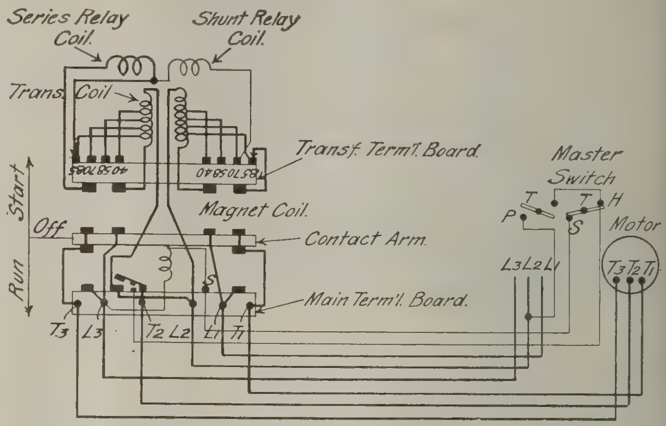


Fig. 12—Diagram of Automatic Compensator for Squirrel Cage Induction Motor

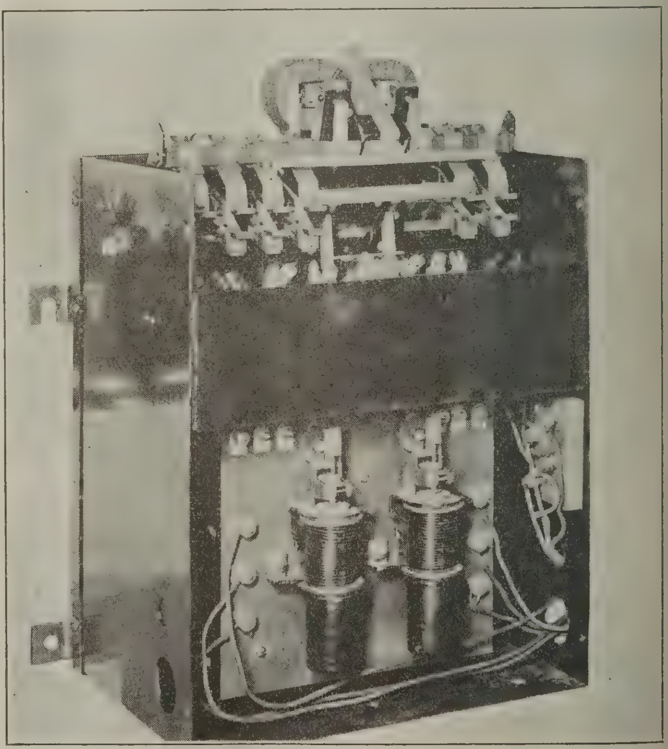
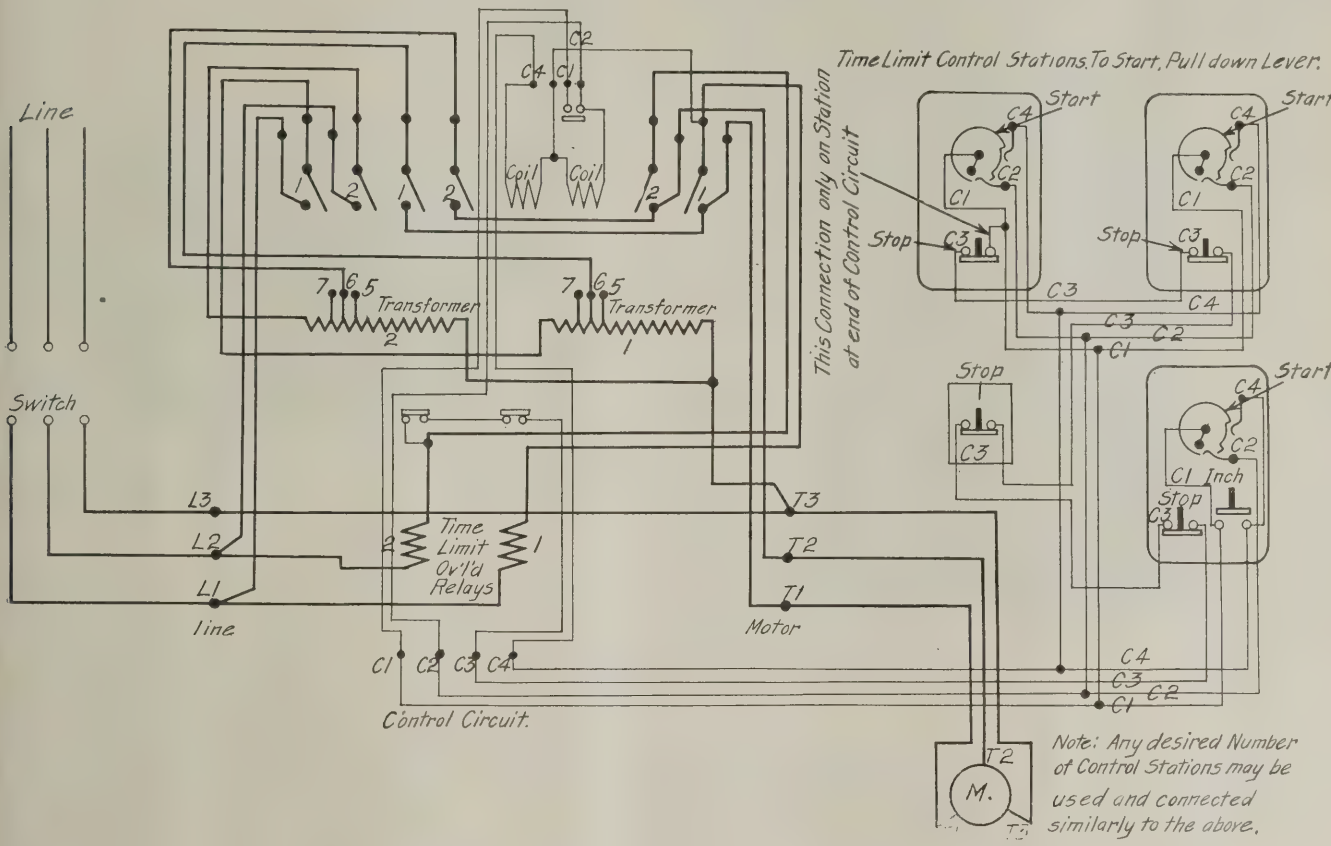


Fig. 13—Automatic Compensator for Squirrel Cage Induction Motor

ciple lies in the fact that, with a time element starter the auto-transformer is in circuit only a given time. With a current limit device a heavy load may prevent the transfer from starting to running position. The auto-transformer then remains in circuit, heavily loaded, and is likely to suffer damage.

The compensator above described is equipped with overload relays which are in circuit for the running position. The motor is thus protected against too severe conditions at the time of transfer or during normal running. The equipment may be arranged for either no-voltage release or no-voltage protection. As many control stations may be used as desired.



Time Limit Control Stations. To Start, Pull down Lever.

This Connection only on Station at end of Control Circuit

Note: Any desired Number of Control Stations may be used and connected similarly to the above.

Fig. 14—Diagram of Connections for Automatic Compensator for Squirrel Cage Induction Motor

The diagram of connections, Fig. 14, shows three stations, one having an "inching" feature and one being a "stop" station only. No-voltage protection is provided. When the starting lever is depressed a control circuit is completed from C3, through overload relays and "stop" contacts to C, thence through start contact to C4. This energizes the magnet closing the starting contacts in the compensator. After an interval this control circuit is broken. At the same time a circuit is made momentarily from C1 to C2, energizing the magnet closing the running contacts in the compensator. A holding circuit from C1 to C2 is then completed by means of an auxiliary contact in the compensator. The compensator now remains in running position unless an overload relay or stop button opens the circuit between C3 and C1 or unless the voltage fails.

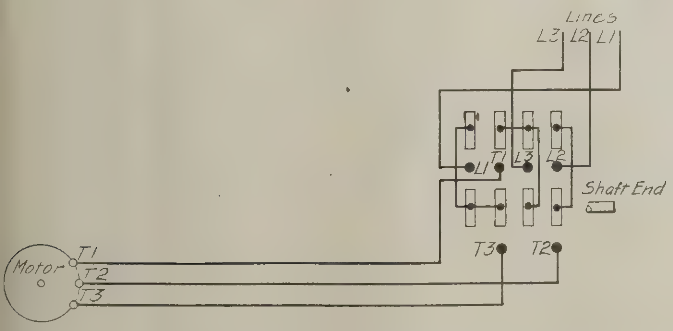


Fig. 15—Drum Type Reversing Switch and Starter for Squirrel Cage Induction Motor With High Resistance Rotor

The devices described above are primarily of the nature of "starters" for squirrel cage motors having a continuous running duty and single direction operation. A switch may be supplied for reversing the primary leads of a polyphase motor, this switch being employed separately, but in conjunction with some form of starting device or compensator. Such an arrangement may not be entirely safe and should be considered only as an emergency measure or in case where reverse operation is very infrequent. Where frequent reversing is to be expected some type of control providing a suitable means for reversing the primary leads is necessary. Drum controllers have been developed for this service. The majority of these drums are for use with small motors or motors having high resistance rotors and suitable for starting by direct connection to the lines. Fig. 15 gives a connection diagram for such an installation.

The control of the wound rotor induction motor involves switching in both primary and secondary circuits. The primary must be connected to or disconnected from the lines. If reversing service is required the primary connections must be reversed. The primary circuit switching may be handled by a circuit breaker, an oil circuit breaker or, if of low voltage, by contacts of a drum controller or face plate. The secondary circuits may be handled by a separate device such as a rheostat with provision for cutting out resistance. Fig. 16 illustrates a face plate controller provided with contact arms and segments for reversing the primary connections and having also three sets of segments and three secondary contact arms connected to cut out resistance in the three phases of the secondary circuit. The connections are shown in Fig. 17. Multiple switch controllers may be employed to cut out secondary resistance. Fig. 18 illustrates such a device for use with an induction motor and Fig. 19 shows the connections. Drum controllers are also frequently used. The connections for a drum controller for varying the secondary resistance of a wound rotor induction motor are shown in Fig. 20. It may be noted that the resistance is not cut out simultaneously and equally in all phases. It is not necessary that this be done. More speed points, with less contacts and complication, are secured by the practice indicated.

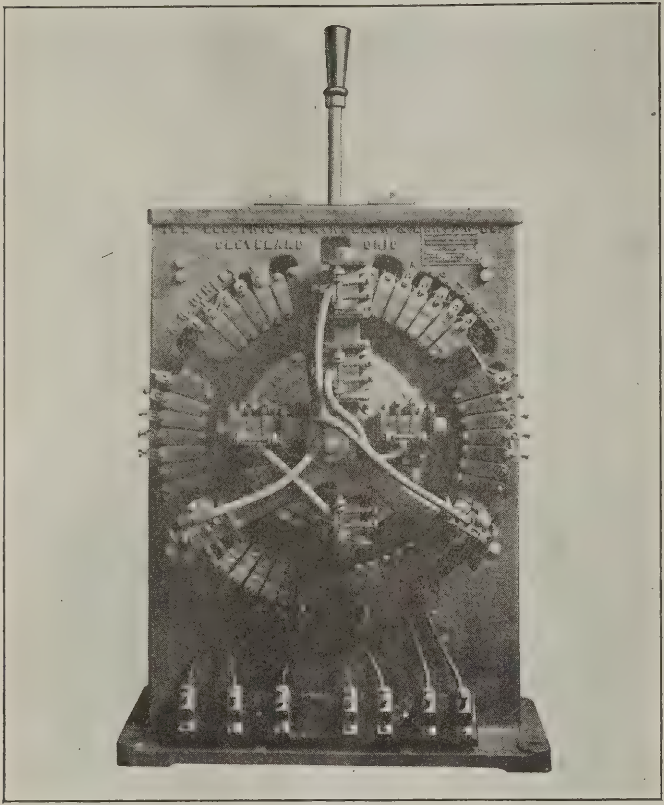


Fig. 16—Face Plate Type Controller for 3-Phase Wound Rotor Induction Motor

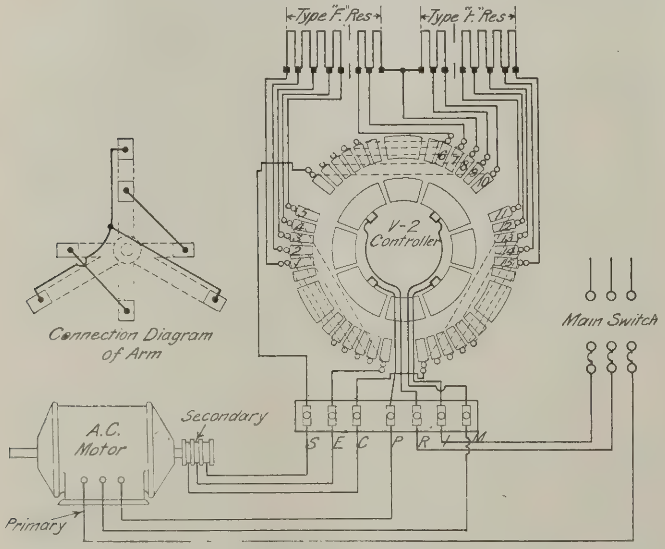


Fig. 17—Diagram of Connections of Face Plate Type Controller for Wound Rotor Induction Motor

A wound rotor induction motor should be started with its secondary resistance in circuit, the resistance being cut out as the motor is accelerated. Where separate devices are used for controlling the primary and secondary circuits, some form of interlock, mechanical or electrical, is desirable.

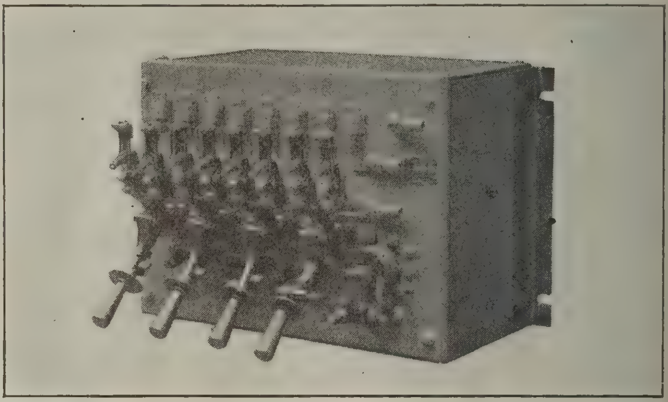


Fig. 18—Multiple Switch Type Secondary Starter for Wound Rotor Induction Motor

Separate devices for control of primary and secondary circuits are commonly used where single direction rotation is desired. When reversing service is required the drum controller handling both primary and secondary connections is more frequent. The use of this type of equipment is not confined to reversing service, however, as it is utilized for single direction service also. Fig. 21 shows the connections for a drum controller handling both primary and secondary circuits of a wound rotor type induction motor. The primary connections are located in the lower portion of the drum and are arranged to be submerged in oil to suppress the arcing.

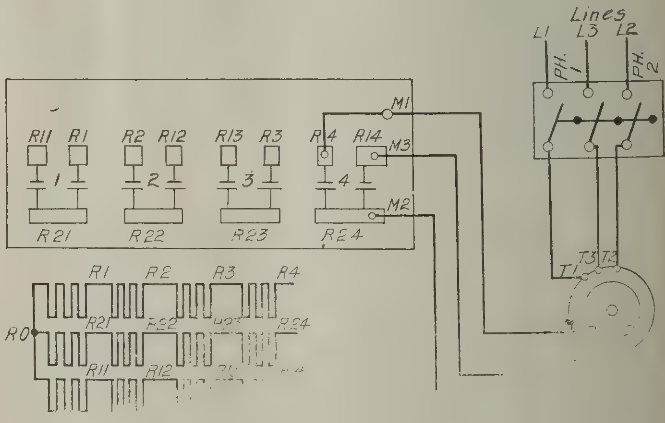


Fig. 19—Connections for Secondary Resistance Multiple Switch Starter

Where the primary circuit switching is done by means of circuit breakers or oil switches, protection for excess current and no-voltage may be provided upon these devices. Where drum type controllers handle the primary switching, separate protective devices must be provided.

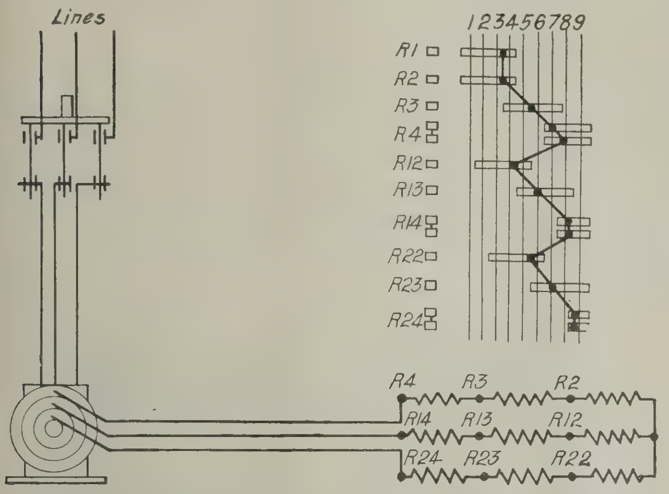


Fig. 20—Connections for Standard Drum Type Starter or Regulator Non-Reversing Type

It is to be noted that the secondary circuits of practically all wound rotor induction motors are three-phase, even though the primary be two-phase. As the stator and rotor are related through a magnetic medium only, this is possible. It results in simplification in lines of motors and controllers.

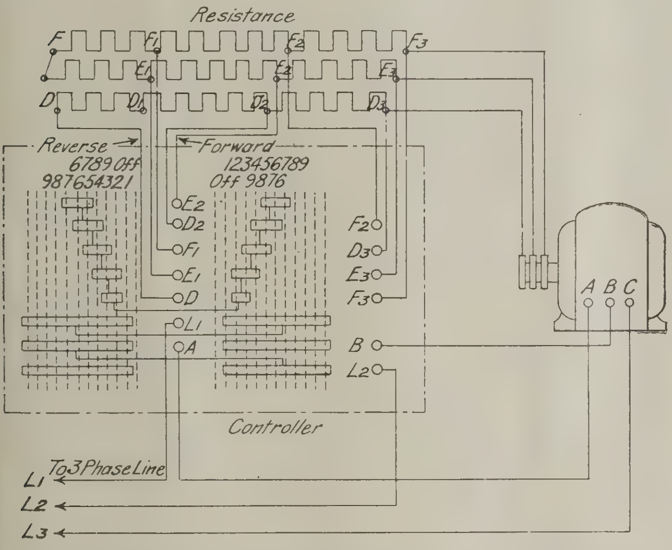


Fig. 21—Diagram of Combined Primary Reverse and Secondary Control Drum

---

An automobile and an aeroplane were recently pressed into service by a dining car conductor, W. Shields, on train No. 49 of the Southern Pacific, running from Los Angeles, Cal., to San Francisco, when his train left him at Fresno. A chase of two miles in an automobile was a failure and Mr. Shields, seeing an aeroplane preparing to ascend nearby explained his predicament to the pilot. At Chowehilla, the train stopped, and Mr. Shields boarded it in time to attend the breakfast service.

Finding Power Factor by Means of Chart

Because of the wider range of reliability there is a tendency toward the use of wattless-component meters, in place of power-factor meters in alternating current plants. The question arises, however, as to how the power factor can be obtained, since it is the desirable quantity to know. Wattless-component means nothing, but it must be considered in relation to the actual kilowatts. This relation is expressed by the power factor; and in the simplest form it may be indicated symbolically as $P.\,F. = \dfrac{W}{V.\,A}$ in which $P.\,F.$ = power factor, W = watts, as indicated on a wattmeter, V = volts, as indicated on a voltmeter, and A = amperes, as indicated on an ammeter.

If the numerator and denominator of the expression $\dfrac{W}{V.\,A}$ are multiplied by K, its value is not changed; in other words, $P.\,F. = \dfrac{K\,W}{KV.\,A}$ in which $K\,W.$ = kilowatts and $KV.\,A$ = kilovolt-amperes.

The relation between kilowatts, kilovolt-amperes and wattless-component can be represented by three sides of a right triangle illustrated in Fig. 1. From this triangle and the equation $P.\,F. = \dfrac{K\,W}{KV.\,A}$ it is evident that $P.\,F. = \cos\theta$, and that $\tan\theta = \dfrac{W\,C.}{K\,W}$ in which $W\,C.$ = wattless-component. By solving the last equation the angle θ can be found by making use of the tables of natural tangents of angles. After the angle is found the natural cosine of angle θ may be found in the tables for cosines of angles. This quantity is the power factor according to the equation $\dfrac{K\,W}{KV.\,A.} = \cos\theta$.

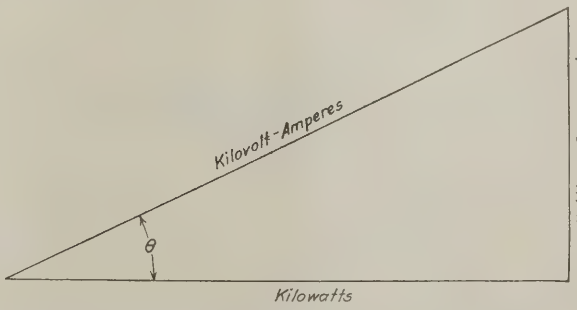


Fig. 1—A Right Angle Triangle Gives the Relation Between Kilowatts, Kilovolt-Amperes and Wattless-Component

Realizing that even this process is slow and somewhat tedious for the busy man and those not familiar with trigonometry, the chart shown in Fig. 2 has been designed to give the desired results quickly and accurately, without calculation or reference to tables.

To use this chart, it is only necessary to find the point on the left-hand scale, which represents the kilowatts, and the point on the right-hand scale, which represents the wattless-component. The straight line that passes through these two points—a stretched thread or a line scratched on a sheet of celluloid will pass through a point on the diagonal line of the chart, which will give the power factor on the upper scale of the diagonal. For example, if the kilowatts are 10 and the wattless-component is 7.5, the power factor will be 80 per cent, as indicated by the dotted line drawn on the chart. In using this chart both vertical scales may be multiplied by the same number. By this means the line joining the two given points may be made to intersect the diagonal at right angles or nearly so, thus making it easy to read the chart. For example, if we have the kilowatts equal to 16 and the wattless-component is 15, the line drawn through the point 16 and 15 as numbered on the chart intersects the diagonal scale at a small angle and it is difficult to read the power factor. In order to get the same result, however, a line can be passed through 8, or ½ of 16, and through 7½, or ½ of 15, which enables the user to read the result of 73 per cent power factor, thus obtain the same reading as if the larger numbers were used.

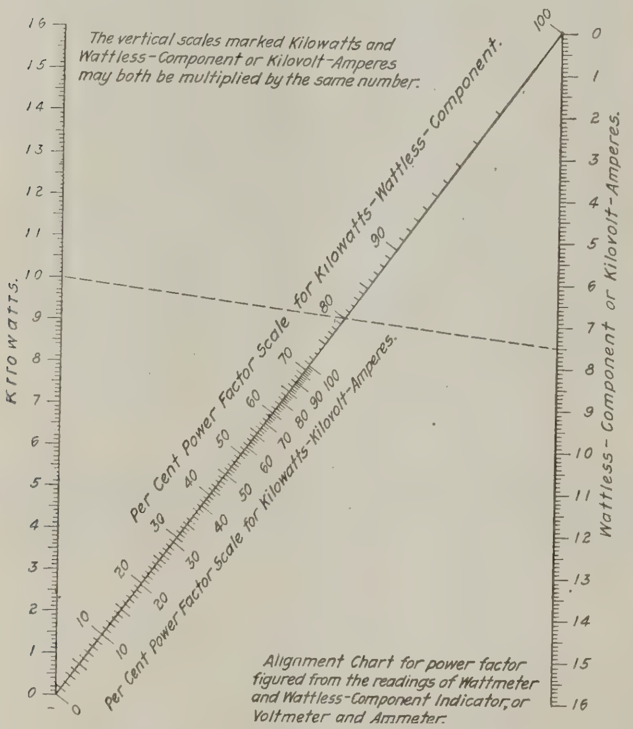


Fig. 2—Chart for Finding Power Factor From Kilowatts and Wattless Component or Kilowatts and Kilovolt-Amperes

On the lower side of the diagonal a scale has been added for obtaining the power factor from the kilowatts and kilovolt-amperes. For example, if the kilowatt meter reads 650 and the kilovolt-amperes, as determined from the voltmeter and ammeter readings, is 800, then a line drawn from 8 on the kilovolt-ampere scale to 6.5 on the kilowatt scale will give a power factor of 82 per cent. There is no special advantage in having this scale on the chart, because the power factor, with these quantities, can just as well be determined on a slide rule. However, since this scale does not interfere with the others, it has been added to the chart, as there may be many times when it will come in handy in determining results when a slide rule is not available.

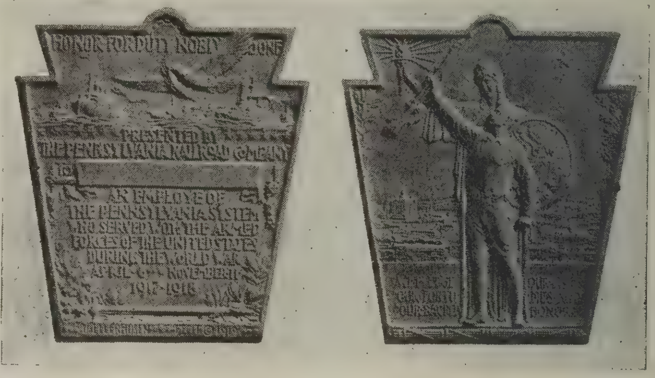
Medals for Railway Employees

The Pennsylvania Railroad has arranged for medals for employees who served in the armed forces of the United States during the world war. If the employee is now living the medal is given to him personally, while if he died in service or subsequently, the medal is presented to his family.

Each medal as it is given out by the railroad is accompanied by a letter from President Samuel Rea, reading in part as follows:

"Appreciating the unselfish patriotism and devotion to ideals and duty shown by the unusually large number of officers and employees of the Pennsylvania System who made great personal sacrifices to serve with the armed forces of our country during the World War, the board of directors desires to commemorate the service so freely given and the duty so well done, and has, therefore, authorized and directed the preparation and distribution of a suitably engraved medal to each officer and employee so serving between the 6th of April, 1917, and the 11th of November, 1918.

"The medal is presented to you herewith, and the hope is expressed that it will ever recall the faithful and effective service rendered by you in the greatest conflict ever waged in the defense of right. In distributing these medals I take pleasure in adding a word of personal thanks and congratulations to each of you, of whom, it is unnecessary to add, I am justly proud."



The Medal Presented to Employees of the Pennsylvania Who Were in Military Service

* * *

Photo Copyright by Paul Thompson

Governor Cox Greets the Railroad Men on His Car at the Pennsylvania Station, New York

English Railway Current Collecting Systems*

A Discussion of This Important Electrification Factor from the English Point of View

Introductory

I HAVE been requested by the Council to read a paper dealing with the contact systems used on electric railways from which the current to feed the trains is collected.

There are two distinct types, the older and the one most generally in use in this country (England) being the conductor or live rail, which is only in use with direct current, at pressures varying from 500 to 1,300 volts, though it is proposed to increase the pressure with this system up to 1,500 volts. A conductor rail with a pressure of 2,500 volts has been tried in the United States but has been abandoned, and so far there are no contact rails working anywhere at a pressure over 1,500 volts.

The general details of conductor rail construction are well known and will only be briefly dealt with at the close of this paper.

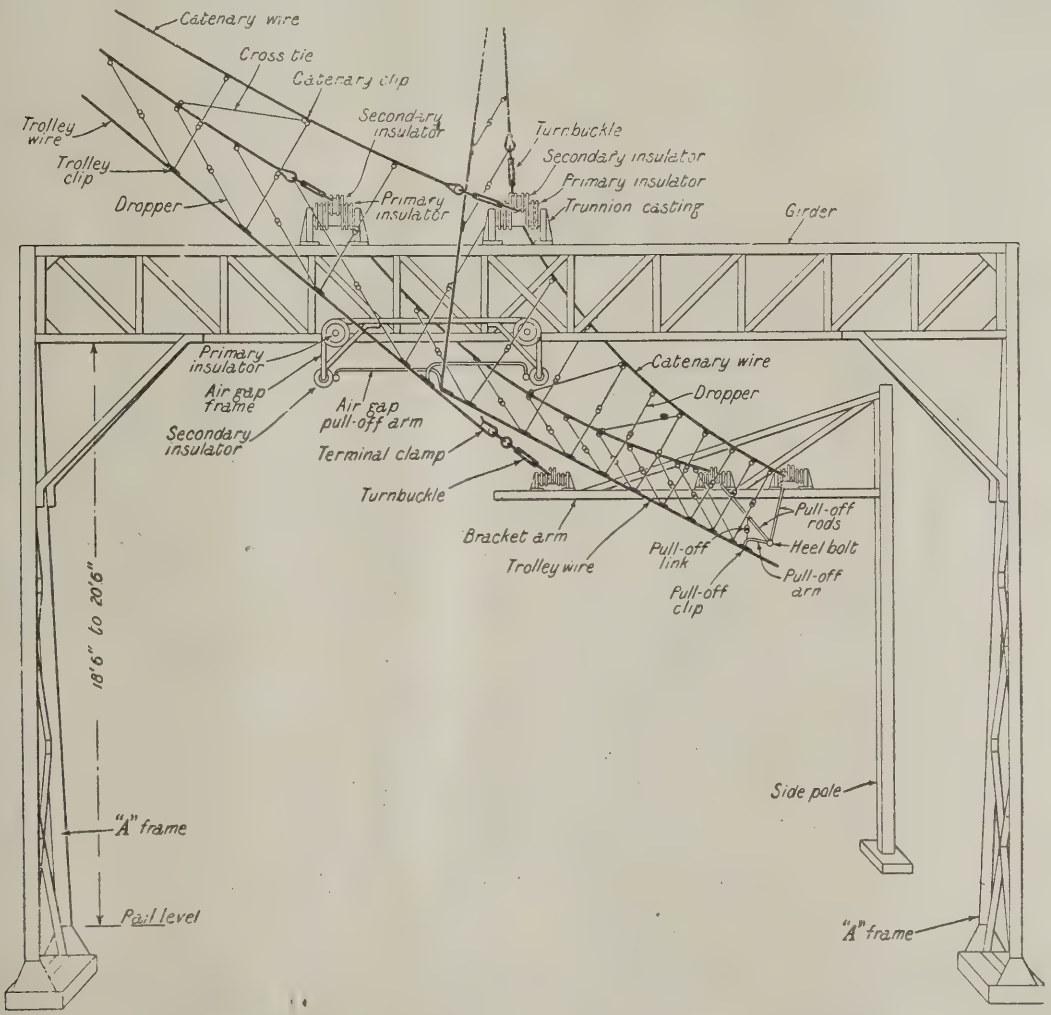


Fig. 1—Overhead Equipment: Names of Parts. Distance Between Standards, 50 ft. to 210 ft.; Distance Between Trunnions, 2 ft. 6 in. to 7 ft.; Distance Between Droppers, 10 ft.; Size of Trolley Wire, 7 ft. S.W.G.; Size of Catenary Wire, Galvanized Steel 12/13 S.W.G.; Size of Dropper Wire, Galvanized Steel, 6 S.W.G.; Strain on Trolley Wire, 18 cwt. at 60 degrees F.; Breaking Strain of Trolley Wire, 22 tons; Elastic Limit of Trolley Wire, 19 tons; Weight per Yard of Trolley Wire, 2.26 lb.; Stagger of Trolley Wire, 9 in. from Center (existing); Stagger of Trolley Wire, 12 in. from Center (proposed); Size of Pull-off Rods, ¾ in. Steam Tube.

Where pressures of 3,000 volts, d.c., or 6,000 to 16,000 volts, a.c., or 3,000 to 5,000 volts three-phase are concerned, the questions of safety and of insulation have made it imperative to use overhead conductors. There is one case in this country where an overhead conductor is used with a pressure of 1,500 volts d.c. The overhead conductor has been used here in order to clear the tracks and yards of live conductor rails.

It is not proposed to discuss the actual question of traction systems in this paper; suffice to say that so far only three countries have decided to standardize any one system for general railway electrification. These countries are Sweden, Switzerland and Germany, who have definitely adopted the single-phase 16,000-volt 16 2/3-period system with an overhead conductor. France is at the present moment investigating the matter, and it appears probable that if they arrive at any definite conclusion, they will adopt the 3,000-volt d.c. overhead system, thus standarizing the voltage as well as the system.

---

*Abstract from a paper by Sir Philip Dawson, read before the Institution of Electrical Engineers, England.

Italy has so far not arrived at any definite conclusion, although the majority of their railways so far electrified are on the three-phase, 16-period, 3,000-volt system. The United States has no definite standard although the Pennsylvania Railroad appears to have decided on the single-phase system for all future electrifications.

The following are the figures regarding the principal electrifications carried out in the United States:

The New York Central & Hudson River Railroad electrified in 1906 with a 600-volt underrunning protected third rail. The mileage of single track electrified today is 258.

The Pennsylvania Railroad electrified from 1905 to 1910 the West Jersey and Seashore, the Long Island and the Pennsylvania Terminal with 600-volt d.c. third rail, the total mileage being 466.

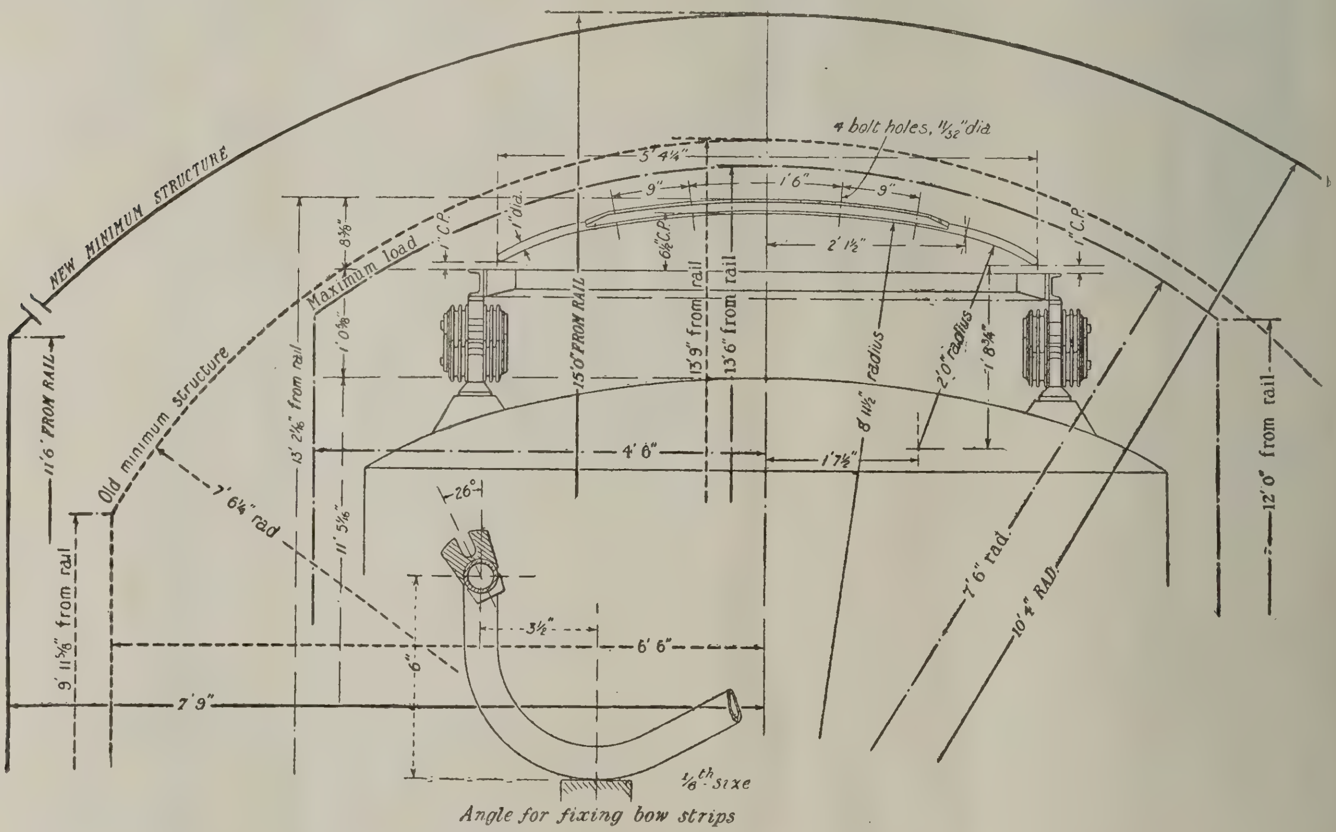


Fig. 2—End View of Bow Gear Showing Clearances

The New York, New Haven & Hartford Railroad electrified at 11,000 volts single-phase, 25 periods, in 1907, 582 miles of single track.

The Pennsylvania Railroad electrified its suburban system in Philadelphia and the Norfolk and Western in 1913 on the single-phase system, 25 periods, at 11,000 volts, and the mileage electrified on this system is now 201, and their extension on the Great Horseshoe Bend is going to be on the same system.

The Milwaukee, St. Paul and Puget Sound Railroad electrified in 1913 on the 3,000-volt overhead d.c. system.

This railroad is mainly a single-track mountain railway using locomotives, and there are so far 647 miles of track electrified.

In this country the whole question is under examination as to how far any one system shall be adopted as a standard for general railway operation.

Dealing with overhead construction for railways in a country where traffic is very intense and the hours of service long, the overhead construction has to be a very different thing from what has been so satisfactorily adopted for electric tramways. In this case it is obvious that the overhead construction must present factors of security and safety at least equal to those obtaining on the permanent way, and it must be constructed in such a way as to enable any maintenance and supervision to be carried out in the very limited periods of time available for such purposes.

An overhead conductor can only be utilized where the currents to be collected from it are relatively small, as experience has shown that heavy currents are not only difficult to collect, but also very greatly increase the cost of maintenance.

Overhead Conductors

General Principles.—The overhead construction and the collector arrangements on the coaches or locomotives must be such as to make it certain that the collector bow will never be liable to come off the contact wire, and must also follow the contact wire with the utmost flexibility, and for this reason the ordinary trolley-wire construction utilized for tramway purposes is obviously unsuitable; in other words, the risk of a collector coming off the contact wire must be no greater than the risk existing today of the wheels of a bogie coming off the track.

The overhead construction must be designed and put up in such a manner that, whilst minimizing the risk of failures, the cost of maintenance and the time required for renewal or replacements of any individual portion requiring attention should be reduced to a minimum; at the same time the capital cost must be kept as low as possible.

In 1907 when the first overhead lines for main-line purposes were being laid out in Germany, in the United States, and by the Brighton Railway, various principles of construction were adopted in order to fulfil the requirements mentioned above, and it is extremely satisfactory to be able to state that whilst considerable alterations have had to be carried out both in the United States and in Germany, the principles adopted in connection with the overhead construction on the Brighton Railway were such that the overhead construction in operation today is practically identical with that originally designed.

The German adopted in the case of the Hamburg Suburban Railway single insulation and a system utilizing counterweights for keeping up the tension of the trolley wire, both of which have proved unsatisfactory for such type of work.

In the United States they at first adopted an entirely rigid form of overhead construction, practically a triangular girder, the three longitudinal members of which were the two catenary supporting wires and the trolley wires which were kept in position by tubular stays. It was found necessary to add a flexible wire under this triangular construction, as the solid conductor wire resulted in hammering and conduced to failures.

On the Brighton Railway the principles adopted in 1907 were:

That the conductor wire should be as flexible as possible and that all hard spots should be avoided.

That double insulation was essential and that the mechanical as well as the electrical factor of safety of the insulators and overhead construction must be very considerable.

That all insulators should be placed in position where they would be least subjected to the direct effects of the hot gases given off from the steam locomotives.

That, with the exception of complicated yards and cross-overs, the Up and Down lines should be sectionalized so as to be able to be cut out independently, whilst the complicated cross-over roads and yards were designed in such a way as to be sufficiently short to be coasted over.

That insulators should be only utilized under compression, and the elastic substances should always be placed between the insulator and its solid support, as well as between it and the mechanical construction which it supported.

Provision was also made when designing the insulators that there might be no possibility of moisture or water collecting and freezing, thereby fracturing the insulation.

The general arrangement in use and the principal parts, as well as their chief dimensions and nomenclature, are shown in the isometric sketch, Fig. 1, which was prepared for the use of the employees of the railway so that they might be familiar with the names and uses of the various parts.

Clearances.—Limiting factors in the erection of an overhead conductor system are the clearances at bridges, in tunnels and under any other structures, which are necessary for electrical purposes, between the live conductors and the loading and construction gages. Fig. 2 shows the various clearances existing today between the live portions of the bow gear, the loading gage, and the old and new minimum structure gages on the Brighton Railway. It will be seen from this diagram that the contour of the bow practically follows the contour of the loading gage, also that under present conditions the ordinary running width of the bow is 18 inches, or 9 inches on either side of the center line. This is the stagger at present adopted for the overhead construction on the Brighton Railway, although for the future, in consequence of the experience gained, this stagger will be increased to a maximum of 1 foot on either side of the center line. The width of the actual collector strip is 9 inches greater on either side of the center line (in addition to the 9 inches allowed for stagger), or 18 inches in all on either side of the center line, in order to allow for the rolling of the coach and for special conditions existing on very sharp curves, and this has been found ample in practice.

The general conditions of clearances which govern our construction are as follows:

Height of live conductor above rail level.—The lowest live conductor on the L. B. & S. C. Railway is 13 ft. 9 in. above rail level, i. e., 3 inches above our loading gage. This happens at Tennison-road Bridge, Gipsy-house Bridge, Boutflower-road Bridge, St. John's-hill Bridge (Up main), and Larkhall-rise Bridge.

This 3-inch clearance has worked quite satisfactorily, though, of course, a minimum clearance of 4 inches between the loading gage and the live wire is worked to when possible. It is considered that 4 inches will be quite satisfactory for 11,000 volts.

Electrical clearances between bow gear and structure.—Four inches is considered to be the minimum vertical point-to-point electrical air clearance which should be allowed for voltages from 6,000 to 11,000; therefore a minimum of 4 inches vertically and 3 inches horizontally is provided from any part of the live bow to a structure at any height after the proper allowance for rolling has been made. The rolling allowance in the case of the Brighton Railway is 5 inches on either side when the center of the bow is at 16 feet above rail level, which is the normal height of the trolley wire.

Electrical and mechanical clearances between overhead equipment and structures.—In this case it is also considered that the minimum point-to-point electrical air clearance from any live part of the overhead line equipment to the structure should not be less than 4 inches vertically and 3 inches horizontally for voltages from 6,000 to 11,000.

There is a case on the L. B. & S. C. Railway where a 2⅞ inches air clearance has been running for a considerable period without trouble occurring. For a long time there were four places with a clearance of from 3 inches to 3⅞ inches and no trouble occurred. Owing to improved construction, and for the sake of standardization, these places have recently been improved to give 4 inches clearance.

Minimum standard clearances.—Working on the principles given above we can get a flexible overhead line construction within a minimum of 10 inches from the loading gage on the structure, i. e., within 14 ft. 4 in. above rail level, which 10-inch space is utilized as follows:

4 inches—Air clearance between loading gage and underside of trolley wire.
2 inches—Depth of flexible line construction.
4 inches—Air clearance between top point of live construction and structure.

There are probably 20 cases of 6 inches overall from the underside of the live wire to the nearest structure, running satisfactorily today; and two of 4½ inches where there is a short space of about 12 feet under the footbridges at Streatham Hill and West Norwood, in which two cases the "live construction" consists of a single trolley wire supported at either end of the bridge.

In practice it has been found that there are a few isolated cases where the clearances required for a live conductor are not available and where the cost of alterations necessitated to procure these would be excessive and would not be justified by the results gained. On the whole of the running lines so far electrified, equivalent to 70 miles of single track, there are only four instances where sufficient clearances for a live conductor do not exist. Three of these occur at the bridges at the entrance to or in Victoria Station, where, owing to the lack of clearance, it has been found necessary to install earthened conductors. One of these bridges just outside Victoria Station—Ebury Bridge—and the two others, are Elizabeth and Eccleston Bridges. The difficulty in this case is accentuated by the fact that owing to men having to circulate on the roofs of steam trains in Victoria Station, the height of the trolley wire inside the station is 19 ft. 9 in. above mean rail level, and the drop from this level to the level under the bridges is 5 ft. 10 in., which is dealt with at a gradient of 1 in 10, as the maximum speed at which the gradients have to be taken does not exceed 25 miles per hour. In order to avoid danger of short-circuits, a neutral section is interposed between the live wire and the earthed section under the bridge. The contours of these sections have been designed in such a way that they take care of the inertia of the bow and the rapidity with which it rises and falls, with the result that there is practically no hammering of the bow when entering or leaving these sections.

One other bridge necessitating a dead section is on the Up side at Knight's Hill, close to West Norwood Station.

Another flat and very low bridge is Larkhall Rise on the South London line, but in this case a live wire is carried through the bridge.

Another very low and difficult structure is Denmark-hill Tunnel, on the South London line.

Other structures are Grove-lane Tunnel at the other end of Denmark Hill, a very low footbridge at Wandsworth-road Station on the South London line, which has had to be raised a few inches, two forms of overhead construction used under one bridge on the Crystal Palace line at Streatham-hill Station, Streatham-hill Tunnel and the standard tunnel construction which has also been applied in the Crystal Palace and Knight's-hill Tunnels, also the entrance to London Bridge.

Sectioning of system.—As has already been mentioned, the line has been divided into sections which can, if necessary, be isolated from each other with a view to locating faults and to minimizing any delay that might be caused thereby.

It is obviously necessary to sectionalize the line, and the only satisfactory manner of doing this without limiting the speed at which trains can traverse such sections is by the use of air-gaps at the end of each section. Under ordinary conditions, and where there are no complicated crossings or junctions, this is a very easy matter, as one conductor can be brought to a terminal and anchored whilst another conductor is started at the point of section, so that the collector bow on a short section runs in contact with the conductor wires of two adjacent sections.

However, at certain points and crossings and complicated junctions this was found to be a very difficult matter. Both in Germany and in the United States this difficulty has been met by putting in section insulators mechanically connecting the adjacent sections. Experience has shown that this method caused flashing and knocking of the bow collector, causing complications and limiting the speed at which such connections can be negotiated. This difficulty has been entirely overcome by the special patented device designed for the Brighton Railway.

It has already been stated that whilst on ordinary running lines the Up and Down lines are easily sectionalized, there are one or two cases of cross-overs, junctions and the yards of terminal stations where this may become difficult, and the special air-gap insulator mentioned above has been of great assistance in overcoming such difficulty. Here the whole of the overhead line is electrically and mechanically connected and formed into what is known as junction sections. Each of the junction sections is separately fed and controlled. These junction sections are so laid out as not to exceed a length which can easily be coasted over should a defect render it necessary for one such section to be cut out.

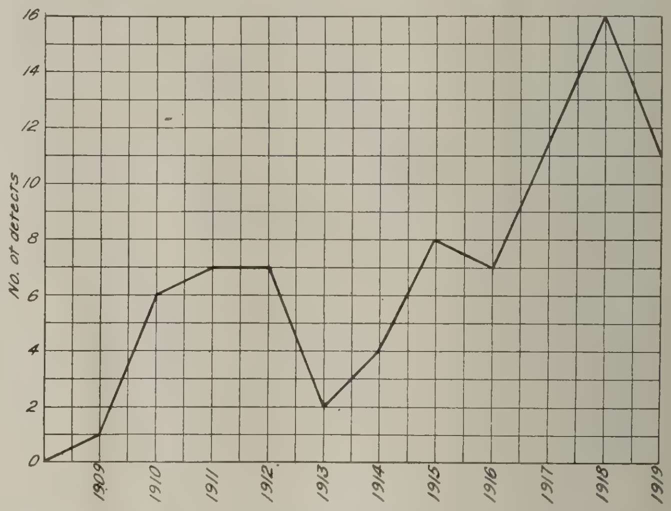


Fig. 3—Overhead Defects Causing Delays to Traffic Working Exceeding Three Minutes

Maintenance.—In connection with the electrification of the Brighton Railway there is one section between Battersea Park and Peckham Rye on the South London line over which there is practically no steam traffic, and which is almost entirely operated electrically, whilst on the other electrified sections, and particularly on the Crystal Palace line, there exists in addition to the electric service a very heavy steam service, which during the years of war was exceptionally heavy on the Crystal Palace line owing to the abnormally heavy munition traffic handled by the Brighton Railway.

As will be seen from the following diagrams which have been taken from the very careful records kept during the last ten years, the maintenance costs and renewals of the overhead construction are very largely affected by steam operation.

The efficiency of the overhead system as regards the very small number of defects and delays arising therefrom is shown in Fig. 3. The larger number of defects in 1911 and 1912 over those in 1913 is due to the fact that the Crystal Palace line was opened in May, 1911, before it had been really properly completed owing to the Festival of Empire, and the drop of defects in 1913 is due to these having been remedied. The rise after 1914 is entirely due to the war, owing to the heavy munition steam traffic over the Crystal Palace line. Even so the defects which caused delays exceeding half an hour are extraordinarily rare.

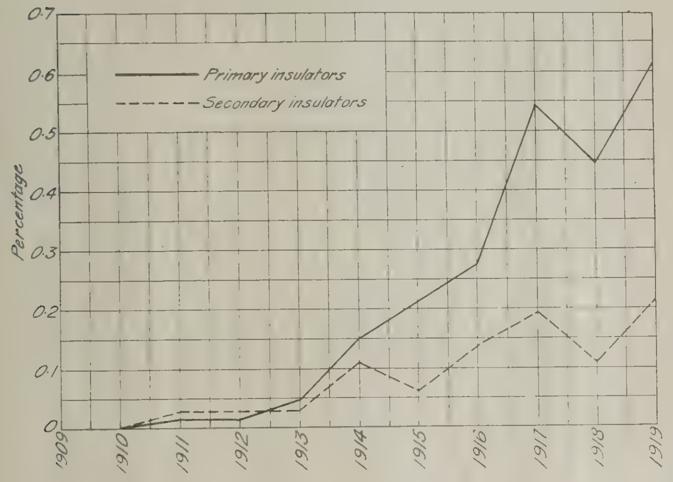


Fig. 4—Percentage Renewal of Primary and Secondary Insulators Per Annum

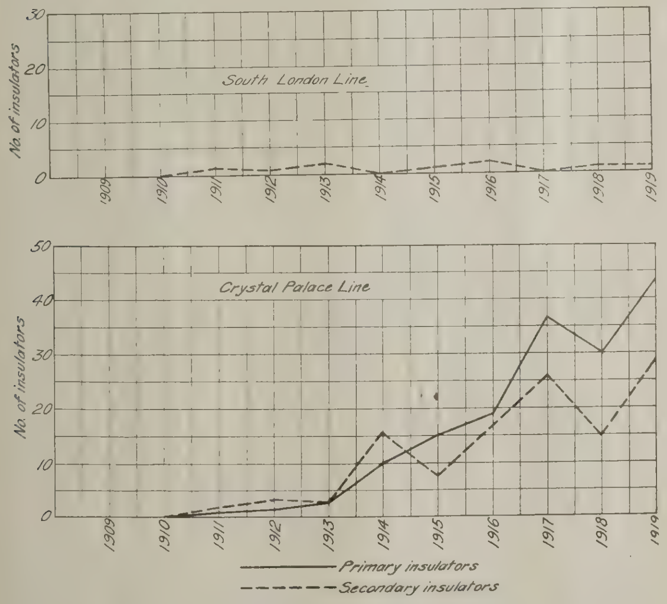


Fig. 5—Insulators Renewed On Account of Stone Throwing, Electric, Mechanical and Steam Causes. 7,000 Primary Insulators and 14,000 Secondary Insulators Are In Use

Fig. 4 shows the percentage of both the primary and secondary insulators renewed on the whole system per annum; whilst Fig. 5 shows the total number and percentage of primary and secondary insulators renewed on the South London and Crystal Palace lines.

It will be seen from the top figure of this latter diagram that not a single primary insulator has been renewed on the wholly electric section of the South London line. Considering that there are altogether 7,000 primary and 14,000 secondary insulators, the result shown can be considered to be eminently satisfactory.

Fig. 6 shows the percentage of trolley wire renewed on the whole of the overhead system since it was first operated electrically in 1909.

As has already been mentioned the wear of the trolley wire is largely if not entirely dependent on the amount of current collected. This is borne out by the actual measurements carried out during the last ten years, the results of which are recorded in Fig. 7. It will be seen from the two top figures of this diagram that the wear on the trolley wire where no current is taken is nearly negligible, and the data given on this diagram are typical of measurements made at a very large number of structures at other places where no current is collected, and are borne out by the amount of trolley wire which has actually had to be renewed during the past ten years.

That the wear is proportional to the amount of current collected is shown by all three diagrams in Fig. 7 and is corroborated by many other measurements made where heavy and medium currents have to be collected.

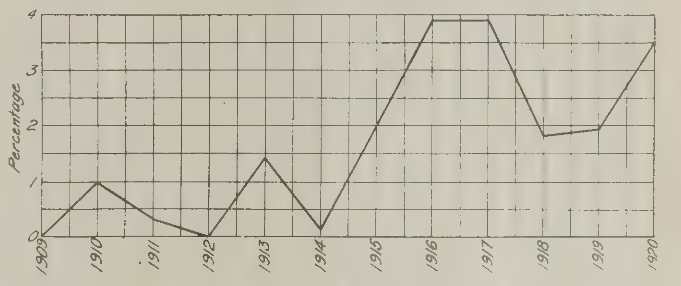


Fig. 6—Percentage Renewal of Trolley Wire Per Annum

Figs. 8 and 9 show the percentage of catenary and dropper-wire renewals during the last ten years. Here again the large increase in these renewals during the years of war is almost entirely due to the extraordinarily heavy steam traffic.

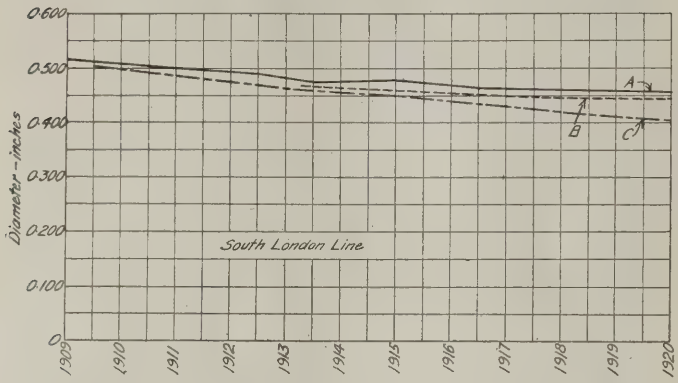
The influence of steam on the maintenance of catenary and dropper wires is clearly shown in Fig. 10. The top figure represents a typical one-mile section of the South London line, which is operated entirely by electric traction, where not a single catenary wire has been renewed. There are 150 miles of catenary wire, so that the amount renewed has been very small.

The two other diagrams in Fig. 10 show two parallel lengths of a mile on the Crystal Palace line, one with very little electric and very heavy steam operation and the other the Local line on which there is a mixed steam and electric service, from which it will be seen that the lines over which there is the greatest steam traffic are subject to the greatest cost of maintenance.

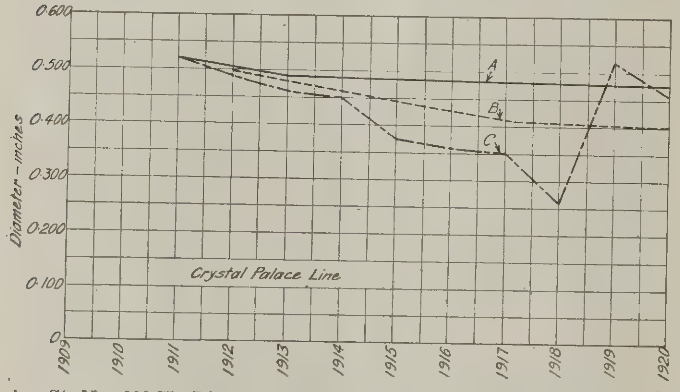
The experience gained on the Brighton Railway, where very great precautions were taken in order to ensure absolute safety of operation, has shown that a simpler form of construction and one which will considerably decrease the cost of construction and maintenance can be adopted, and one has been designed and tried and will be employed in connection with any extensions which may be carried out.

Conductor Rails

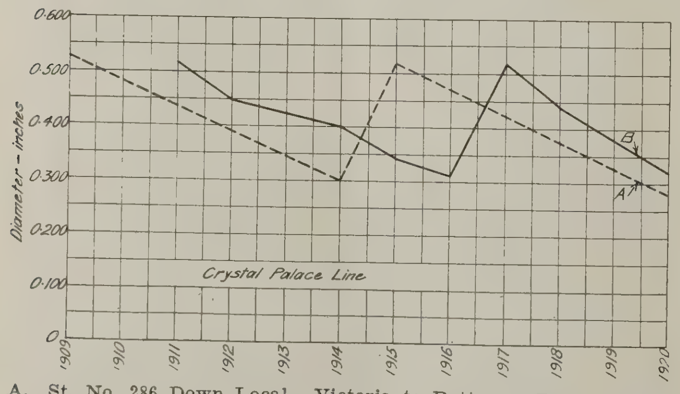
(a) General remarks.—When we deal with the question of conductor rails, it may be observed that owing to the large mileage of these installed in this country there is a very considerable amount of information available regarding them which has been published from time to time both in papers which have been read before the various institutions and in articles published in the technical press.



A. St. No. 214 Down Line. East Brixton to Clapham Road. No Current.
B. St. No. 189 Up Line. East Brixton to Clapham Road. Running Current.
C. St. No. 170 Down Line. East Brixton to Clapham Road. Starting Current.



A. St. No. 666 Up Line. Gipsy Hill to West Norwood. No Current.
B. St. No. 587 Up Local. Clapham Junction to Battersea Park. Running Current.
C. St No 568 Up Local. Clapham Junction to Battersea Park. Starting Current.



A. St. No. 286 Down Local. Victoria to Battersea Park. Lower Part of Grosvenor Bank. Heavy Running Current.
B. St. No. 666 Down Line. West Norwood to Gipsy Hill. Starting Current.

Fig. 7—Relative Wear on Trolley Wire

(b) Types of conductor rails.—At the present moment there are three types of conductor rails in general use if we consider them from the point of view of form of current collection.

Over-running, where the shoes rests on the top portion of the rail, being kept there by means of gravity or springs, as is the case on the Underground Railway system, the London and South-Western, the North-Eastern, the London and North-Western, and the Lancashire and Yorkshire Liverpool-Southport line.

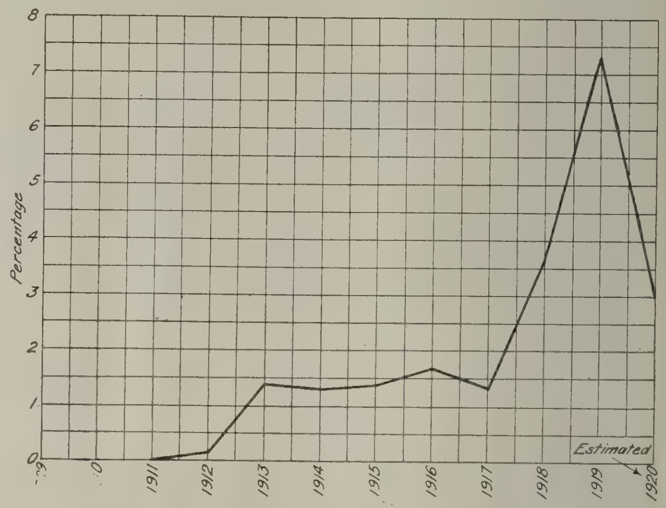


Fig. 8—Percentage Renewal of Catenary Wire Per Annum

Under-running, where the current is collected from the lower surface of the rail, the rail being supported from the top and the contact being pressed upwards by means of springs against the conductor rail. This system is not at present in use in this country, although installed to a very considerable extent in the United States and on the Continent.

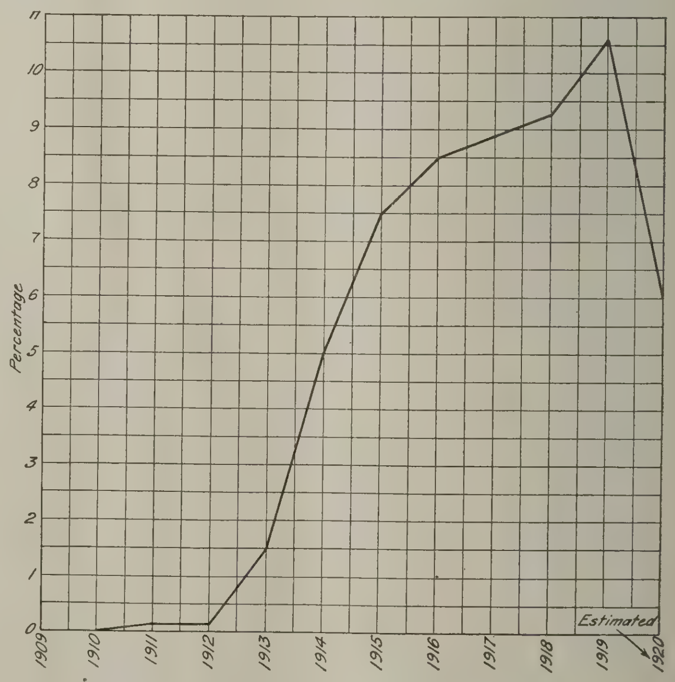
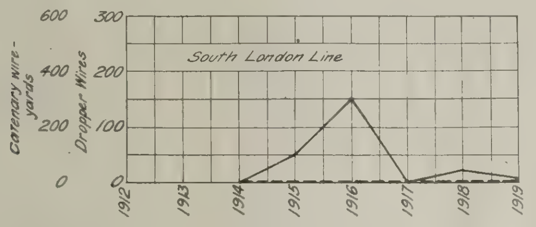


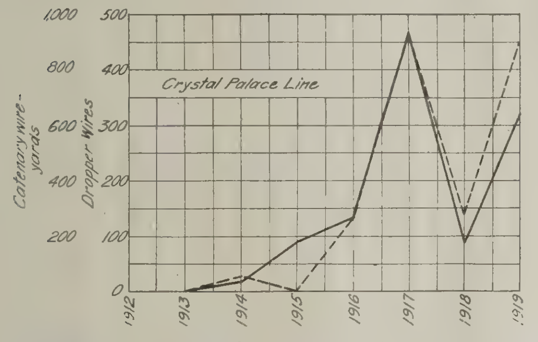
Fig. 9—Percentage Renewal of Dropper Wires Per Annum

Side-running, such as was designed and installed by Sir John Aspinall on the Manchester-Bury section of the Lancashire and Yorkshire Railway, where the current is collected from the side of the conductor rail by means of a collector pressed laterally against the conductor rail by means of springs.

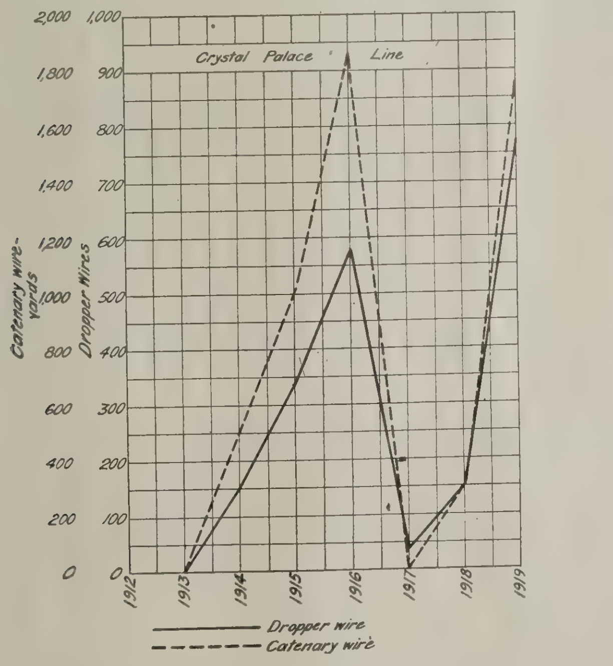
(c) Some construction details.—Conductor rails have to be interrupted at crossings and at complicated portions of the track, and in order to enable trains to leave and again make contact with the conductor rail at high speed either vertical or lateral ramps have to be installed to bring the collector shoe into gradual touch with the conductor rail.



St. No. 150-185 Down Line. Approx. 1 Mile.



St. No. 560-530 Down Local Line. Approx. 1 Mile, Clapham Junction. South box to near Wandsworth Common Station. Heavy Electric Service; Medium Heavy Steam, Passenger and Goods Service.



St. No. 560-530 Down Main Line. Approx. 1 Mile, Clapham Junction South box to near Wandsworth Common Station. About 1 per cent Electric Service; Very Heavy Steam, Passenger and Goods Service.

Fig. 10—Relative Renewal of Dropper Wires and Catenary Wires; 100,000 Dropper Wires and 150 Miles of Catenary Installed

Jumper cables have to be provided in order to connect electrically the different sections of the conductor-rail system, and experience has shown that where possible these should be laid either above ground or on the surface, so as to be easily accessible from the point of view of repairs and maintenance. Provision has also to be made by means of section switches or links to sectionalize the conductor rail so as to be able to isolate portions of it when required, in order to renew or repair portions of the track or in case of derailment.

The shape of the conductor rail varies very much and no standard exists for this at present, neither has any standard yet been definitely adopted by all railways for the height or actual position of the conductor rail.

The rails must be of a special chemical composition so as to give the highest conductivity consistent with durability.

Referring to the question of gaps, with pressures up to 1,300 volts, no very great troubles with over-pressures have so far been encountered owing to contact shoes making and breaking contact, and it is therefore quite possible to coast over lengthy gaps where multiple-unit trains are used. This becomes difficult if not impossible where electric locomotives are used to haul heavy loads and where a gap would mean a complete interruption of energy to the train. In order to overcome this difficulty both on the New York Central and Hudson River Railroad, and on the Pennsylvania Railroad, on complicated sections where the conductor rail has had to be interrupted an overhead construction to carry an overhead conductor rail has had to be installed.

With conductor rails operating to 600 volts, experience has shown that under normal conditions no protection is required or advisable, and, in fact, there are many cases where such protection having been originally installed has now been removed, not merely to reduce the cost of maintenance but because it has been found that a conductor rail without such protection formed a smaller obstruction to the operating staff than a protected one. Notwithstanding the great mileage so far installed, the number of fatal accidents due to persons coming into contact with the conductor rail is very small, and such accidents have more generally occurred in the case of trespassers than of employees.

Where, however, a pressure of 1,200 or 1,500 volts is in use, the conductor rail must be protected, and a very suitable form of protection for a side contact has been adopted by the Lancashire and Yorkshire Railway on their Manchester-Bury section.

The most suitable material for this protection in this country has been found to be Jarrah wood.

Whilst on certain railways in certain cases it has been found necessary to anchor the conductor rail, experience on other lines seems to show that this is not always either necessary or desirable.

Insulators at present in general use are made of porcelain, earthenware, "Siluminite," reconstructed granite and various other substances, and the normal spacing is somewhere in the neighborhood of 9 feet or 10 feet apart.

The only serious delays which have so far been caused in this country in connection with the conductor-rail system are in the case of those railways where top contact is made when abnormal weather conditions have caused the rail to be covered with a thin layer of ice. So far this difficulty appears to have been overcome either by under-running or by side-running.

As regards the question of wear and tear, it is very difficult owing to the varying conditions of climate, operation and location, to come to any definite conclusion, but experience in the open air on the Metropolitan District Railway would seem to indicate that the loss of rail due to wear and tear and corrosion may be taken at something like 1 lb. per yard per annum, half of which is due to wear and the other half to corrosion.

(d) Systems for conductor rails.—So far as the systems of conductor rail adopted in this country are concerned, it may be said that there are two definite principles at present in operation and a third has been proposed. In the case of the Metropolitan and the Metropolitan District Railways, owing to the fear of the drop in the return circuit being limited to such a figure by the Board of Trade as to make it difficult to realize with an ordinary track rail return, these railways have adopted double conductor rails, one positive and the other negative, the track rails not being utilized as a part of the return circuit. This arrangement has brought about certain defects in connection with insulation of the apparatus on the trains, particularly when the negative conductor rail becomes earthed from any reason, due to over-pressures. The necessity of using two insulated conductor rails obviously increases both the capital and maintenance costs of the conductor system.

The other system is that adopted by the North-Eastern, the Lancashire and Yorkshire, and the London and South-Western Railways, and is one where only one insulated conductor rail is employed, the track rails being utilized for the return circuit either with or without a supplementary bonded rail or return conductor. This additional rail is bonded to the track rails and serves merely for carrying current and is not insulated from earth.

With a view to getting the benefit of 3,000 volts pressure, but at the same time not having to utilize any motors wound for a higher pressure than 1,500 volts, and in order to do away with any large currents returning through the track rails, Mr. Raworth, the electrical engineer of the South-Eastern and Chatham Railway, has proposed the adoption of a conductor-rail system requiring two insulated conductor rails per track, the track rails serving as a neutral. A similar system has been running for some years on the Nord-Sud line in Paris, which operates with an overhead conductor and insulated conductor rail, the difference of potential between these being 1,200 volts, and the track rails serving as neutral of a three-wire system.

Voltage Drops in Earth-Return Circuits

(a) Direct current.—The permissible voltage drop in the earthed return is the most important factor in the case of direct and alternating-current systems of traction.

At the present time there have been very considerable departures from the original standard as dictated by the Board of Trade for maximum voltage drop in rails of electric tramways where direct-current systems are concerned. The maximum allowance of 7 volts imposed on tramways has compelled such railways as have electrified under parliamentary powers, and who feared similar regulations being imposed upon them, to install insulated return-current conductor rails.

Other railways not so situated are operated with rail drops perhaps exceeding for short periods twenty times that figure. Either, therefore, the Board of Trade limit, as imposed on tramways, is unduly severe if applied to railways, or there is an amount of damage going on by way of electrolysis which must sooner or later involve considerable trouble.

Since substation distance, and therefore the economic operation of direct and alternating-current systems, are directly affected by rail drop, a time seems to have arrived when some decision should be taken on this point. The anomaly of one railway being afraid of being limited to a 7-volt drop while another is unrestricted should be removed.

(b) Alternating current.—At one time it was considered that alternating current had no harmful effect so far as electrolysis was concerned, and in any case this effect is very small compared with direct current.

The Board of Trade has recognized that a higher pressure drop can be admitted with alternating than with direct current. The first regulation laid down was 200 volt-minutes for a period not exceeding ten minutes, which means that for short periods the drop may be twice as much. The question of cost is very largely governed by the number of substations, and this in its turn is governed by the maximum drop allowed in the track return.

The limitations of rail drop are therefore governed by considerations of economy and of inductive effects. The latter have not proved by any means so troublesome as had been prophesied, the effects of rail impedance being largely counterbalanced by the comparatively small current transmitted in the alternating-current system.

Conclusion

It is not the intention of this paper to make any comparison between the merits or otherwise of conductor rails and the overhead system, but merely to give information, particularly as regards overhead conductors, about which at the present moment very little is generally known in this country. It is, however, obvious that the presence of a charged rail near the track must increase the cost of maintaining the permanent way, and this is borne out by the fact that men working on track with a charged rail have been authorized to receive special extra pay at the rate of 2s. per week.

As regards overhead conductors, this difficulty is done away with except for the painting of the valances of the roofs at stations near which the live conductor passes. There will be a slight increase in the cost of painting these, due to the presence of the live conductor; but this will obviously be insignificant compared with the increased cost of maintaining permanent way, due to the presence of the conductor rail.

The controversy over the relation between intrastate and interstate passenger fares now being conducted in many states where state regulatory commissions have declined to grant intrastate passenger fares to conform with interstate rates recently granted by the Interstate Commerce Commission held a prominent place in the deliberations of the thirteenth annual meeting of the National Association of Attorneys, held at St. Louis, Mo., on August 23 and 24. The association, however, made no recommendation concerning the issue.

Electrical Distribution at Engine Terminals

A Saving is Obtained by Using Standard Methods; Employees Readily Adapt Themselves to Equipment

By H. L. Cornelison
Electrical Equipment Engineer, Austin Company, Cleveland, Ohio.

IN the construction of several new engine terminals for the Pennsylvania Lines, considerable progress has been made through the standardization of electrical distribution for both light and power. The scheme of electrical distribution for a 30 stall engine house at Crestline, Ohio, is illustrated diagrammatically in Fig. 1. The engineering for standardization of the lay-out was performed by the railroad, under the direction of R. Trimble, formerly chief engineer of the Pennsylvania Lines West, now assistant chief engineer of the Pennsylvania System; while the construction of the terminal and the installation of the electrical service was undertaken and recently completed by the Austin Company, Cleveland, Ohio. A view of the roundhouse during construction is shown in Fig. 2.

The power house at Crestline Yard comprises, in addition to the boiler room, the heater fan room, the smoke exhaust fan room, the boiler wash equipment room, an electrical repair room and the air compressor room, the latter being used also for the main switchboard room containing the control panels for the electrical distributing system of the plant. Just outside the boiler room and immediately adjacent to the compressor room is an outdoor substation with concrete base on which are mounted the master transformers for stepping down the incoming current for distribution through the control panels located in the compressor room.

Power Service and Distribution

At Crestline and at most of the other new engine terminals the railroad company purchases electrical energy from local power companies. In the majority of cases, three-phase, 60 cycle, alternating current is furnished and distributed throughout the yards at 2200 volts.

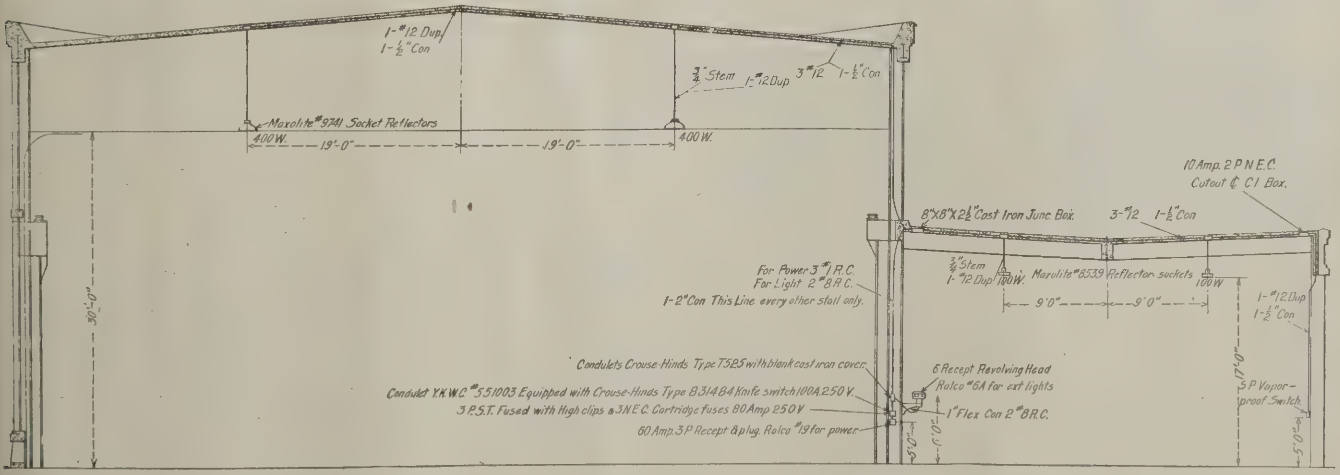

1-#12 Dup
1-½"Con
¾"Stem
1-#12 Dup
3-#12
1-½"Con
Maxolite #9741 Socket Reflectors
400W.
19'-0"
19'-0"
400W.
30'-0"
For Power 3-#1 R.C.
For Light 2-#8 R.C.
1-2"Con This Line every other stall only.
Condulets Crouse-Hinds Type T525 with blank cast iron cover.
Condulet Y.K.W.C. #551003 Equipped with Crouse-Hinds Type B31484 Knife switch 100A. 250 V.
3 P.S.T. Fused with High clips & 3 N.E.C. Cartridge fuses 80 Amp 250 V
60 Amp. 3 P Recept & plug. Rolco #19 for power
5'-0"
8"X8"X2½" Cast Iron Junc. Box.
3-#12
1-½"Con
10 Amp. 2 P N.E.C.
Cutout & C.I. Box.
¾"Stem
1-#12 Dup
100W.
Maxolite #8539 Reflector sockets
100W
9'0"
9'0"
1-#12 Dup
1-½"Con
17'-0"
S P Vapor-proof Switch.
6 Recept Revolving Head
Rolco #6A for ext lights
1" Flex Con 2-#8 R.C.
6'-0"
5'-0"

Fig. 1—Cross Section of Engine House Stall Showing Location of Lighting Outlets, Receptacles and Switches

It is the custom of the Pennsylvania to purchase its own transformers and measure the current consumed through meters installed on the primary side at the receiving voltage. This potential varies for different locations as might be expected; the range is from 2,200 to 66,000 volts, the latter being the pressure at which current is supplied to Crestline Yard.

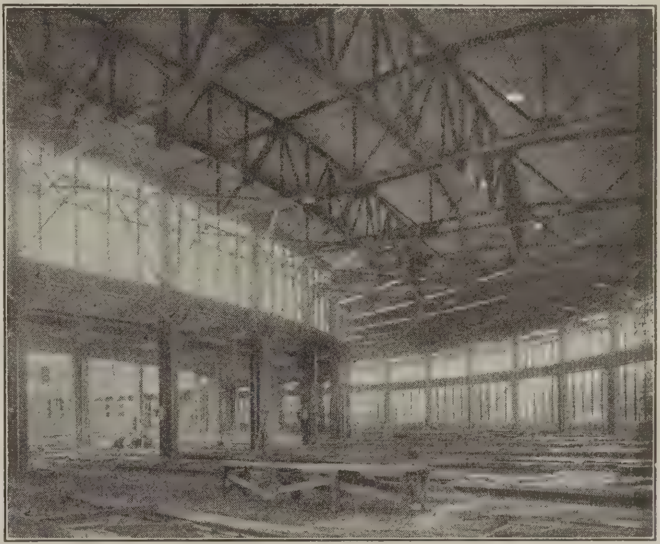


Fig. 2—Engine House During Construction. The Conduits for the Overhead Lights are Embedded in the Roof Slabs

A central bank of three 200 kva. 66,000-2,200-volt transformers, arranged for out-door service, is used to step the receiving voltage down from 66,000 to 2,200 for yard distribution and for the various buildings as required. The arrangement of this equipment is shown in Fig. 3. Of course, where current is received at distribution pressure, this central bank of transformers is not required.

The distribution of energy to the office building, power house, oil house, storage building, machine shop and inspection pits is effected by placing 2,200 volt transformers at the approximate centers of load areas in which energy is required. At these points the voltage is stepped down to 220 for power and to 120-208 for lighting purposes. In the latter case a three-phase, four-wire system is used.

In general there are three classes of distribution, separately controlled at the 2,200-volt switchboard. These are, (1) current for all power purposes (2) current for interior lighting and (3) current for all exterior yard lighting. All of these various loads are supplied with energy from a single bank of transformers where the service pressure, as at Crestline, makes the transformers necessary. The standard protective equipment for this outdoor substation includes an automatic over-load release, oil circuit breaker, and aluminum cell lighting arrester, together with auxiliary apparatus such as current transformers, potential transformers, choke coils and disconnecting switches. All of this apparatus is of the outdoor type.

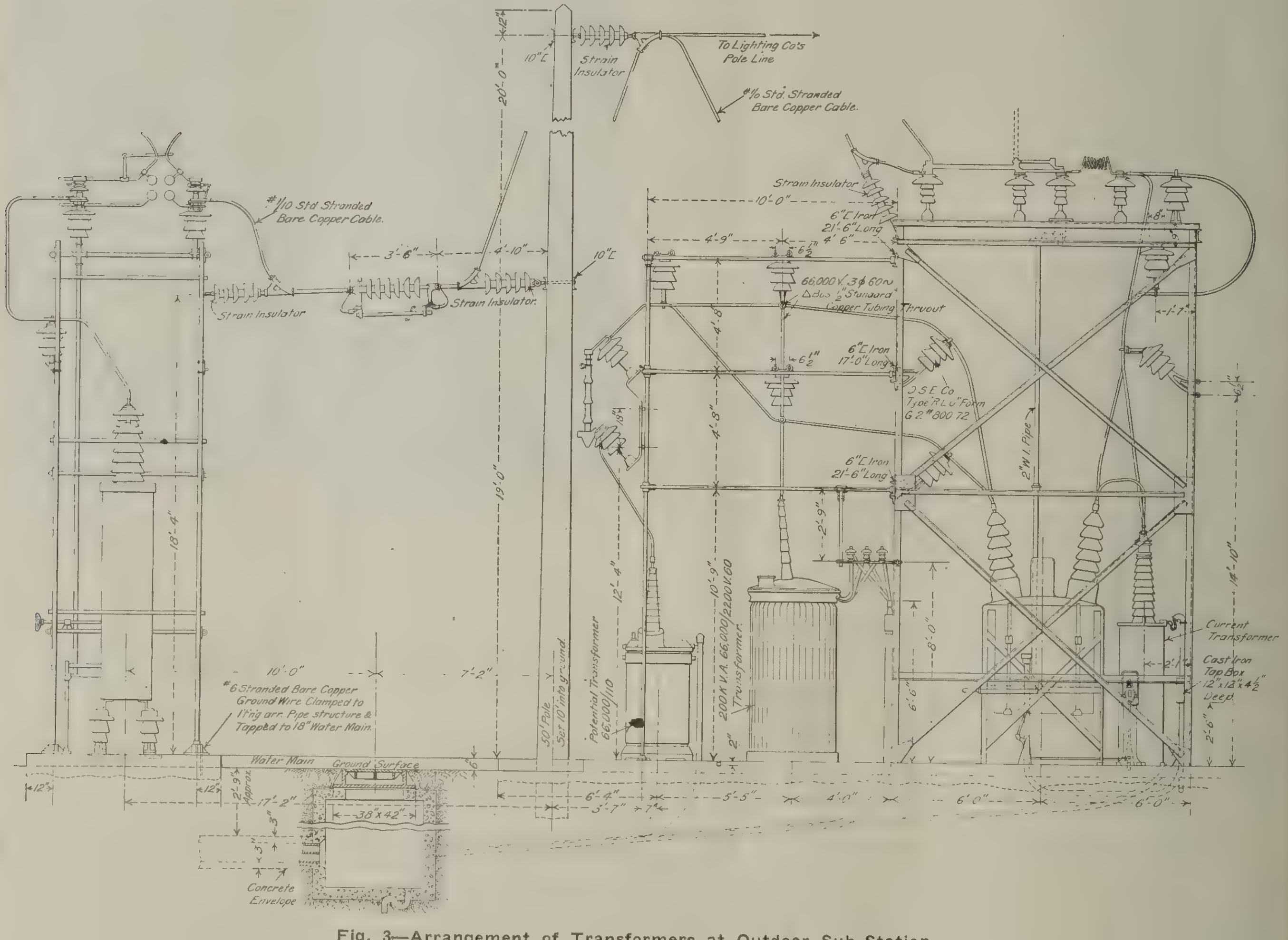


Fig. 3—Arrangement of Transformers at Outdoor Sub-Station

An incoming line panel on the main switchboard in the compressor room is provided with a watt-hour demand meter, a curve drawing power factor meter, an indicating ammeter and static ground detector. The feeder panels are equipped with oil switches on the incoming lines, each switch being provided with an overload release. In addition to this, the power circuit breakers are equipped also with a low voltage release as a precaution against injury in case full voltage is re-established after partial or complete interruption has occurred for some reason in the current supply.

To facilitate the making of connections and to avoid the crossing of wires behind the switchboard, a vault is built below the floor level back of the switchboard in which the feeder lines terminate. From this vault the feeders are carried underground to the terminal poles near the power house, up the poles to the cross arms, where connections are made to the overhead distributing system, which, in general, is the system employed. However, where congestion prevails, the circuits are placed in underground conduits, as is done also wherever a track crossing is encountered. Field transformers, for stepping the voltage down from a distribution pressure of 2,200 volts to the required amount for delivery to the lamps and motors, are usually mounted on pole platforms, although exception is made where the capacity of these transformers is such as to make them exceptionally heavy, in which case concrete mats are utilized such as those at the out-door substation. For the smaller transformers, primary cutouts are provided, while the larger ones are equipped with disconnecting fuses. Lightning arresters are installed at transformer locations for the protection of both high and low tension sides where the lines are overhead. The poles are set in concrete in order to further the permanence of the line construction.

The Application of Power

At each of the terminals a steam generating plant is maintained for the purpose of heating the buildings, operating the boiler washing system, etc., the heating being done by the indirect hot air method. The fans for blowing the air over the heating coils are steam-driven, as is the usual standard practice. All other apparatus, however, is electrically driven. This includes the blowers, where forced draft is used, the ash handling equipment, the exhaust fans for the down-take system of smoke collection in type "A" houses, as at Crestline, and the air compressor, as well as machine tools, cranes, turntables, etc. All of the motors are of the three-phase induction type operating at 220 volts, with the exception of the motors for the smoke exhaust fans, which are 2,200 volt, and also the 2,200-volt synchronous motors which drive the air compressors.

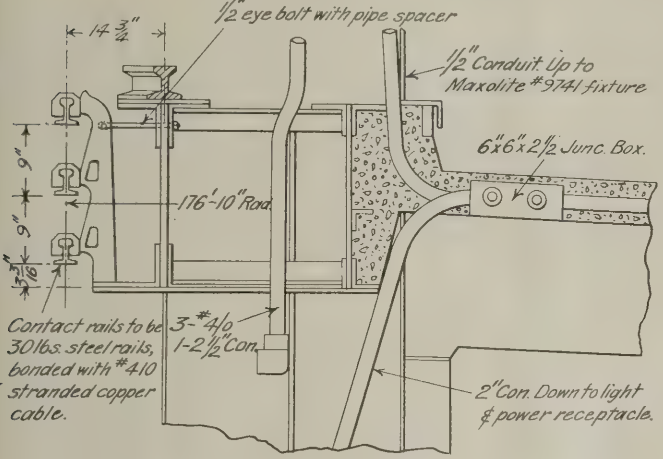

1/2" eye bolt with pipe spacer
14 3/4"
1/2" Conduit Up to Maxolite #9741 fixture
6"x6"x2 1/2 Junc. Box.
9"
9"
3 3/16
176'-10" Rad.
Contact rails to be 30 lbs. steel rails, bonded with #4/0 stranded copper cable.
3-#4/0 1-2 1/2" Con.
2" Con. Down to light & power receptacle.

Fig. 4—Section Showing Contact Rails

In the engine-house, the motor-driven apparatus consists of overhead traveling crane, which is a striking feature of the type "A" house, the drop pit mechanism, the turntable tractor, the electric welding apparatus and such portable tools as may be required. The scheme of power transmsision to the engine-house crane motors is a matter of interest in that, since the crane operates on a circular track, the usual form of trolley wire is not suitable because of its making tangents between points of support. On this account three 30-lb. rails supported one above the other have been substituted as shown in Fig. 4; these are bent to the contour of the inner crane supporting rail and suspended from the frame work by means of insulating brackets. The collectors on the crane make contact with the rail bases from underneath. Turntable motors are supplied with current by both the overhead and the underground system, as may be preferable in each case.

For portable tools a single three-pole receptacle is mounted on each second column, and from these also are operated the portable electric welding outfits, which consist of 220-volt a.c. motors driving d.c. welding generators. Such crane equipment as is used in the machine shop receives current through triple copper wire trolleys. The motor equipment at the coal docks is of the same general character as elsewhere, an important feature of the plant being the control apparatus, whereby the machinery is automatically set in motion and subsequently stopped by merely pushing a button. Wiring throughout the coal docks is in rigid steel conduit with cast iron fittings to make the work permanent and secure.

An additional electric power feature of the Crestline terminal is the gantry crane for handling ashes at the cinder pit. This is illustrated in Fig. 5. The main trolley wires for this equipment consist of copper strung between poles along one side of the pits. Because of the corrosive action of the vapors arising from the pits the usual copper trolley wires on the crane bridge have been replaced with steel shapes, which are less susceptible to injury from this cause.

Illumination of Engine Terminal

The energy for lighting these engine terminals, as disclosed at the beginning of this article, is furnished at 120-208 volts and a four-wire, three-phase system of distribution is employed. For all interior illumination incandescent lamps mounted in porcelain enameled steel reflectors are used. For general interior illumination these reflectors are of the diffusing type, while for local illumination at machines or by means of extension cords, reflectors of the intensifying type are provided. For each stall in the engine-house there are two 400-watt lamps suspended from the roof trees in the high bay and two 100-watt fixtures suspended from the roof in the low bay; the inner and outer row of lights are on the circuit controlled from a main switch at the door, while the other two are controlled from the door of each stall, for which a control switch is mounted on the door post. For portable lights, conduits are installed down the main roof supporting columns, terminating in turret fixtures, in each of which are receptacles for six separate extension cords. In the machine shop, in addition to the general illumination, provision is made for such special lighting as the work in hand may require. This is accomplished by means of extension cords, and also by means of more permanent fixtures at tool locations.

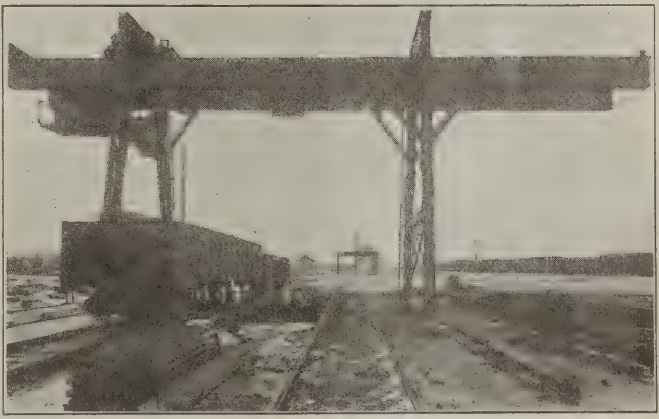


Fig. 5—Gantry Crane for Hauling Ashes at Cinder Pits

Conduits for interior wiring are imbedded in concrete, wherever such construction was possible, whether it be in the roof, as in the case of the general lighting units, or in the floor, as for individual motor-driven tools. Cast iron junction boxes and fittings are employed in all buildings entered by locomotives.

Exterior illumination is effected through the use of the flood lighting system. For the turntable this involves the use of a 500-watt fixture at each approximate quarter circle. These consist of irregular surface reflectors of the

Davis type in cast iron housings, mounted on towers on the roundhouse roof to elevate them to a height of 35 ft. above the track. Opposing lights are focused one against the other, so as to avoid shadows. Yard illumination is provided by employing a bank of 1000-watt flood lighting fixtures consisting of parabolic glass reflectors of the Davis type mounted in cast iron housings. These are placed in groups on poles at an elevation of 65 ft. above ground level. No fixed rules regarding pole location has been adhered to; the arrangement being in accordance with local requirements and preference. In this case, also, opposing lamps are focused one against the other, to reduce the glare and shadows. For these lighting circuits special transformers are provided at suitable locations to step down the voltage from 2,200 to 110.

Special care has been taken in wiring the oil house to have all circuits tightly sealed in conduits, so as to diminish the fire hazard from short circuits and sparks. The switches and panel boards are mounted outside of such buildings for the same reason. This provision adds greatly to accessibility in case of emergency.

Besides the Crestline Yard project, a number of other terminals have been constructed along the lines mentioned. Among the larger ones are the new engine terminal and yard at Richmond, Ind., a new locomotive erecting and machine shop at Logansport, Ind., and remodeling of the old engine house. The standardization of electrical distribution for these terminals resulted in a reduction in the cost of engineering and construction. The employees adapt themselves to the equipment with comparative ease and when transferred from one terminal to another they are already familiar with the workings of the standard layout.

The Scope of the Headlight

Now that the electric headlight generator has become so extensive in its use, it would be indeed surprising if new applications for it were not discovered from time to time. J. Henry Schroeder of the Sunbeam Electric Manufacturing Company tells of one of these interesting applications which was recently brought to his attention. Some time ago there occurred on the Louisville, New Albany & Corydon Railroad a derailment of several cars and the resultant wreckage was considerable. In order to clear away the wreck with any degree of efficiency, an abundance of artificial light was required. Several extension lights were run from the turbo-generator set on the locomotive and so efficiently illuminated the scene of the wreck that one of the company's officers stated that the labor it saved paid for the outfit.

Some of the roads have already equipped their wrecking trains with electric headlights and it would seem that in consideration of the above incident it would be a splendid idea if the practice were made general. That the electric headlight equipment on the locomotive will prove to be a decidedly versatile apparatus cannot be doubted and from time to time we expect to hear of new and unusual applications made of it.

New York State Leads Nation in Hydro-Electric Output

Among outstanding facts derived from figures recently issued by the division of power resources of the Geological Survey covering the production of electric power and consumption of fuel by public utility power plants in the United States for the first four months of 1920 is that New York State leads in hydro-electric output, the monthly total for that state reaching 268,736,000 kw.-hr. for April, against 292,336,000 kw.-hr. produced by fuel. California ranks second in production by water power, with 219,475,000 kw.-hr. for April, figures which show a good recovery from the low total of 148,836,000 kw.-hr. in February, caused by conditions of drought; Montana comes third, with 100,008,000 kw.-hr., and Washington fourth, with 95,672,000 kw.-hr.

The total production for April for the nation is put at 3,590,071,000 kw.-hr., divided as follows: By water power, 1,488,948,000 kw.-hr.; by fuels, 2,101,123,000 kw.-hr. For the four months totals are: By water power, 5,351,103,000 kw.-hr.; by fuels, 9,316,135,000 kw.-hr.; total, 14,667,238,000 kw.-hr. These figures are based on returns received from about 2,800 power plants of 100 kw. rating or more engaged in public service, including central stations, electric railways and certain other plants.—*Electrical World.*

Columbia University, New York City, announces a special course of instruction, under Dr. T. W. VanMetre, in railway traffic management, the aim being to educate men for service with large shippers.

* * *

Photograph from Underwood & Underwood, N. Y.

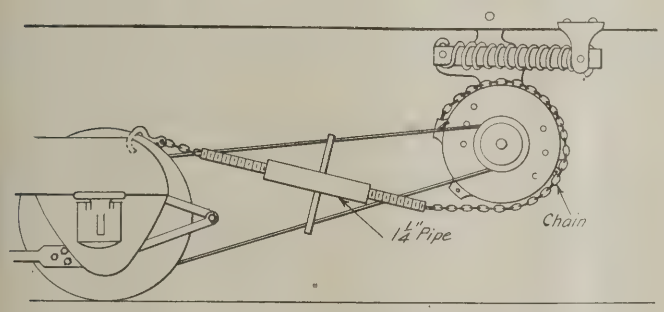
A Workingmen's City on Wheels

PRACTICAL STUNTS

A Device for Putting On Car Lighting Belts

By Warren E. Neely

One method that has been found to work successfully in drawing up a car lighting generator in order to slip on the belt, is illustrated in the sketch below. The device consists of a home-made turnbuckle which has been constructed from scrap material which is usually available in most any yard. The turnbuckle proper consists of a piece of 1¼-in. iron pipe about 30 in. long. Into each end of this pipe are welded pieces of iron about three inches long which are then bored out and tapped for ⅝ or ⅞ bolts having five or six threads to the inch. The threads in one end of the pipe should be left-hand threads, if possible, in order that the turnbuckle will take up more rapidly. However, if left-hand taps and dies are not available it may be necessary to make one end of the turnbuckle without any threads by welding in a piece of iron with a swivel eye in the end in order that it may be readily attached to the chain. The other end of the turnbuckle will be threaded and will draw up the slack of the chain, thus drawing the armature axle toward the car axle, making it possible to slip on the belt. This device, as used by the car lighting men at Camden, N. J., is threaded on one end with a left-hand thread and on the other end with a right-hand thread. Threaded bars of iron move in and out of the pipe thus shortening and lengthening the chain as desired. A small hand lever consisting of a piece of iron through the center of pipe, as shown in the sketch, is used in order to turn the device and lengthen or tighten the chain.

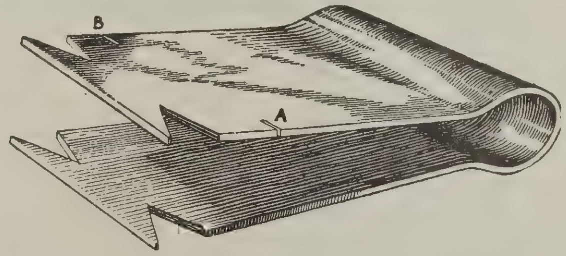


A Turnbuckle Made from 1¼ in Pipe for Putting on Belts

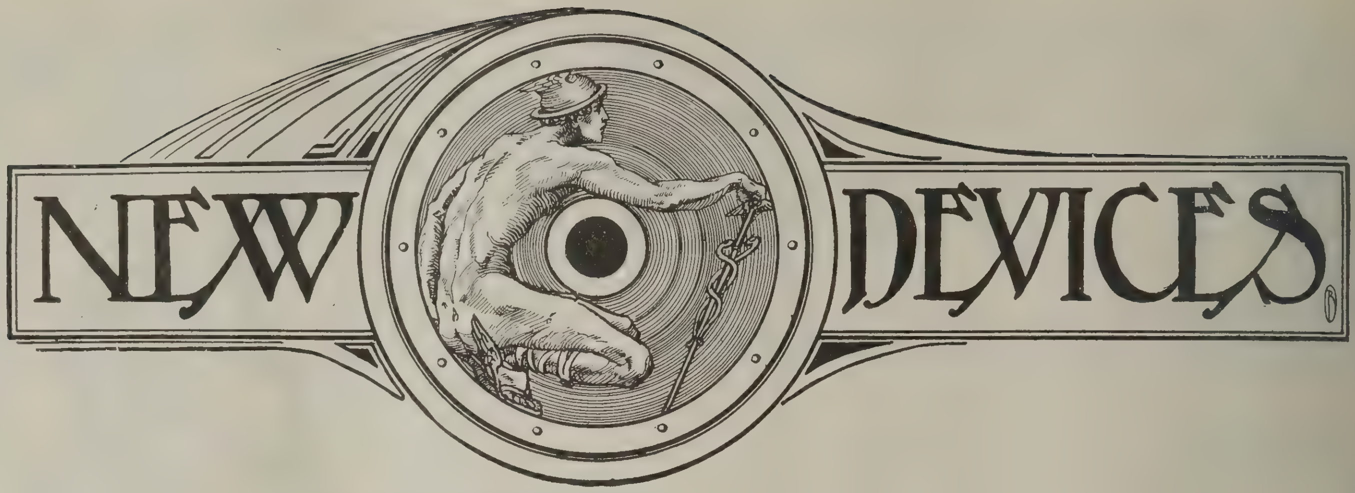
Putting on car lighting belts is something which every car lighting man has to contend with and it would be interesting to learn of the various devices which the different roads have adopted to accomplish this result. We should, therefore, be very glad to have other devices of this nature sent to us for publication as they are bound to be instructive to car lighting men of every locality.

Commutator Segments Cut With Templet

It is the practice in many shops to cut mica for commutator segments by first laying out one of the segments on a sheet of mica and marking out the desired form, after which the segment is cut out with a pair of shears. A method which has been tried and proved successful was described in a recent issue of *Power*. This method consists, essentially, of a templet designed to conform to the segments used. It is capable of holding a number of sheets of mica which, when gripped in a vise, will permit the use of a hacksaw to cut the V's, etc. The old method even at the very best does not produce segments that are of uniform shape. If a rigid construction of the commutator is to be obtained, not only must the insulating segments be of the proper thickness but the V's in them must be uniform in size and shape as well as the parts of the segment on the inside of the commutator. The templet used in the new method consists of a piece of 1/16-in. iron bent into the shape shown in the illustration. After this has been done the two sides of the templet are gripped in a vise and the V's cut to the exact shape of the commutator for which the insulation is being cut. A notch is cut at *A* to indicate the maximum width of the mica and another notch is cut at *B* to give the minimum width. The mica is cut to the approximate width of the segments, and then the templet is filled tight with these strips. While being held in a vise, the insulating segments are cut to the required shape with a hacksaw. A notch is cut in the mica at *A* and *B* to give the maximum and minimum widths, so that after the segments are removed from the templet the excess material can be cut off with a pair of shears.



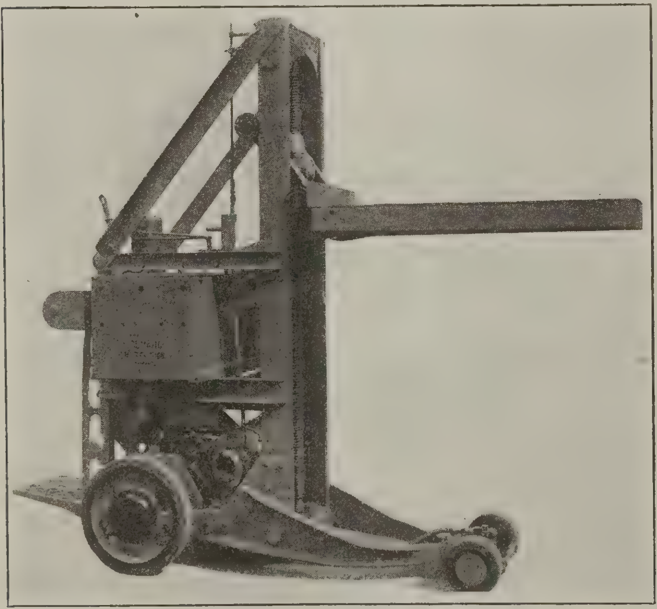
The Templet for Cutting Mica Insulation for Commutator Segments



NEW DEVICES

High-Lift Elevating Platform Truck

A high-lift elevating platform truck known as "The Tiering-Lifting Truck," is being offered by the Transportation Engineering Corporation, 200 Fifth Avenue, New York. The truck is essentially an electric elevating platform truck with the added feature of lifting or tiering the load from one inch to six feet. Platforms in standard heights used with electric lifting platform trucks may be used with this machine. The truck has a guaranteed capacity of 4,000 lbs. and is furnished in various heights up to a maximum height of 95 in. The truck frame is built of hot riveted structural steel and is supported on the rear axle by two steel coil springs, each encased in a box. The frame carrying the supporting columns is of cast steel. The truck is guided by a four wheel steering arrangement.



Tiering-Lifting Truck of 4,000 lb. Capacity

The load platform is carried on cantilever type supports and is hinged to prevent damage in case the platform is lowered on some obstacle. It is raised and lowered by a steel screw, revolving in a large bronze nut carried in a trunnion, which is provided with an oil magazine for lubrication. The fully loaded platform elevates at a speed of one inch per second. The movement of the platform is controlled by a simple reversing switch working in conjunction with a brake on the elevating motor shaft and cut-outs are provided for stopping the platform automatically when the load reaches the highest or lowest position.

Power from the driving motor to the driving wheels is transmitted by a single reduction steel-to-bronze worm and wheel running in a bath of oil and a full floating axle. The working parts wherever possible are carried on ball and roller bearings and are mounted in oil tight, dust proof housings. Both the elevating and traction motors are series wound, 24 volt, 45 ampere motors running at 1700 r. p. m.

The driving controller is of the drum type and permits three speeds forward and three reverse. Current cannot be applied to the motor without first releasing the brake. The brake is of the external contracting type equipped with asbestos fabric lining and is operated by a foot pedal.

The driving wheels are 20 in. in diameter with a 3½ in. face, the front wheels are 9 in. by 5 in. and all are equipped with pressed on rubber tires.

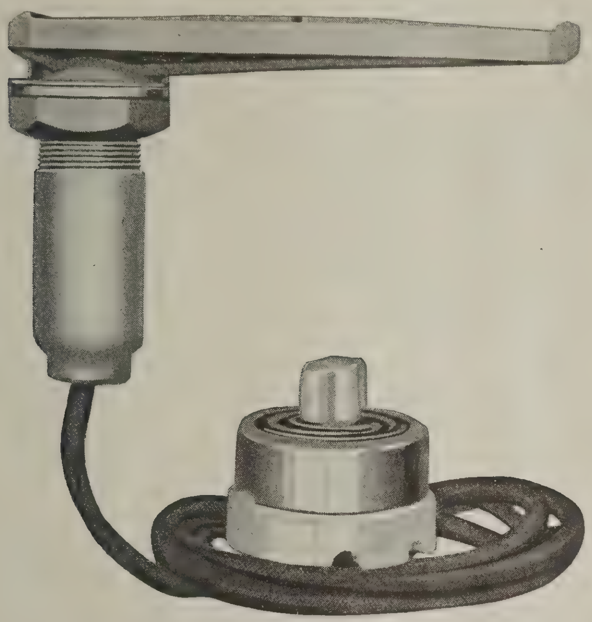
New Immersion Heater

A new immersion type water heater, shown in the illustration, consists of nickel chromium heating elements encased in a flat brass casting which protects them from mechanical injury. The casting is about 3 inches by 6 inches by ½ inch in size, and makes a simple and durable heater from which is easily cleaned any sediment that may be deposited from the water. When protected in this manner the life of the heating elements is increased, requiring less frequent renewals than with the ordinary immersion type heater, so the manufacturer states. This heater is well adapted for use with sterilizers, glue pots, paste kettles, stills, etc.

Projecting at right angles from one end of the casting is a hollow extension carrying locknuts and washers and through which runs the extension cord.

To install the heater, a 1¼-inch hole is drilled through the bottom of the container and the heater inserted from the top, so the extension through which the cord is run projects downward through the hole. Tightening the nuts and washers holds the heater rigid, and prevents leakage.

By means of a snap switch on the heater cord three different heats may be obtained: 1,200 watts, 600 watts, and 300 watts. If more than 1,200 watts are desired, two or more heaters may be used in the same container. Standard heaters are made for 110, 120 and 220 volts, and may be used on d. c. or a. c. circuits. The heaters are manufactured by The Cutler-Hammer Mfg. Co., of Milwaukee and New York.



Immersion Type Electric Water Heater, for Mounting in the Bottom of the Container

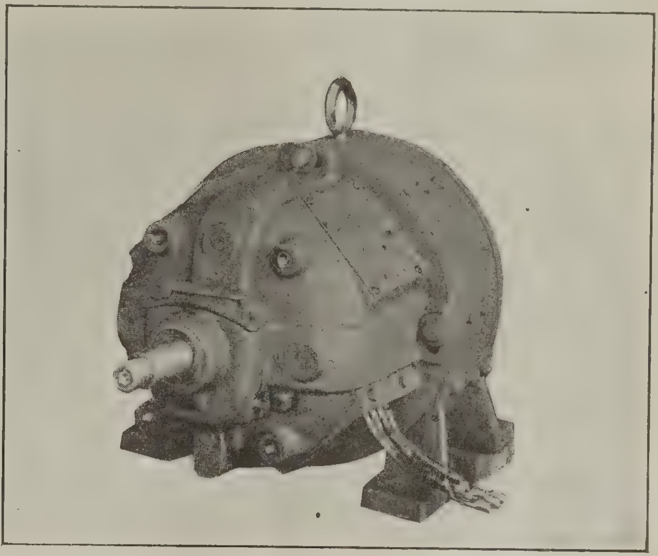
D.-C. Series Motor for Crane and Hoist Service

For intermittent, varying speed service where heavy starting torque is required, such as for cranes and hoists, the Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa., has recently brought out the type HK direct-current, series-wound motors. These motors are especially designed for use where the work requires a series of starts, stops and reversals, the motor being idle for only short periods of time. The motors are of enclosed construction with small openings in the lower part for ventilation. Openings in the top half of the frame give access to brushes and commutator.

The HK motor has a forged open-hearth steel frame and solid forged-steel feet. The motors above 3 hp. rating are equipped with commutating poles so that high momentary loads can be carried without sparking, and long life of the commutator and brushes is thereby insured. All field coils are thoroughly insulated and impregnated. The brackets are strong and rigid, each being complete with an oil well and bearing housing. Oil ring lubrication is used. The brush holders are clamped to insulated rods mounted on the front brackets, which are dowelled in place. The position of the brushes is thereby fixed for both directions of rotation.

Armature coils are form-wound and thoroughly insulated and impregnated before being placed in the slots. A blower is placed in the rotor which effectively ventilates both the armature and the field windings. This allows a smaller diameter armature to be used, resulting in low flywheel effect, consequently little energy is required to start and stop the motor, thereby reducing to a minimum wear and tear on the bearings and brakes.

The ability of any motor to do its daily work, as far as temperature rise is concerned, is determined by the continuous rating it will carry at a safe temperature. A ventilated motor has a larger continuous rating than a non-ventilated motor of the same short time rating. A ventilated motor rated at 7½ hp. one-quarter hour, has about 30 per cent more continuous capacity than the non-ventilated motor rated at 7½ hp. one-half hour. In order to utilize to advantage the ventilated feature, the HK line of motors has been rated on the one-quarter hour basis. Comparison of the whole line shows that on this basis the motors have a larger continuous rating than the non-ventilated motors of the same half-hour rating.



Type H-K Series Wound D. C. Motor

Extra Large Condulets

To meet the demand for a condulet having an unusually long cover opening and big wiring chamber, the Crouse-Hinds Company, Syracuse, N. Y., has designed a new series known as the Mogul condulets, which are shown in their bulletin No. 1000 N. These condulets are designed to avoid kinking heavy wires or cables when pulling in or feeding through a conduit system, and to afford ample space for making splices or taps. Though liberal in their proportions they do not materially affect the general outline of the conduit system. Their hubs have integral bushings and tapered threads. Fastening screw holes are located at the ends of the cover openings.

Mogul condulets are made in eight types, each type in eight conduit sizes ranging from one to four inches. There are four sizes of composition and cast iron covers, each size being common to two sizes of condulet bodies. The composition covers are made with from one to nine wire holes, or blank covers are furnished which can be drilled by the user as required. The cast iron covers are made in two types; with gasket, or without gasket. The gasket is made of round rubber, cemented into a groove in the cover. The cover fastening screws are furnished with and secured to the cover.

General News Section

Captain George B. Malone, formerly engineers, U. S. A., now general manager of the K-G Welding & Cutting Company, 556 West Thirty-fourth Street, New York City, has recently taken charge of the Philadelphia office of the company at 929 Chestnut Street, Philadelphia, Pa.

Julius Janes, formerly president of the Standard Steel Castings Company of Cleveland, has recently concluded an arrangement with the Farrell-Cheek Steel Foundry Company of Sandusky, Ohio, by which he will be the sales representative of this organization in Cleveland and Cuyahoga County.

A. B. Way, until recently secretary and general manager of the Bridgeport Chain Company, has become affiliated with the Chain Products Company of Cleveland, Ohio, in the capacity of district sales manager for New England, with headquarters at the company's New York office, 150-152 Chambers Street.

Rickard and Sloan, Inc., New York, N. Y., announces the removal of their office from the Evening Post Building to 25 Spruce Street, at William. The Rickard and Sloan agency are specialists in technical advertising. The business of the company has outgrown its quarters at the Evening Post Building, making it necessary to find new and larger offices.

The Roller-Smith Company, New York, N. Y., announces that its Baltimore representative, the Perkins-LeNoir Company, 113 East Franklin Street, has added to its sales force C. H. Mohr. Mr. Mohr was formerly connected with the Westinghouse Electric & Manufacturing Company. He will devote his attention to the electrical measuring, protective and control apparatus handled by the Perkins-LeNoir Company, specializing in the Roller-Smith products.

The Department of Commerce, Washington, D. C., has just published Circular No. 92, of the Bureau of Standards, on "Operation and Care of Vehicle Type Batteries." This circular or book was prepared with the co-operation of the construction division of the Army War Department for the purpose of providing a manual of instruction for the care and operation of storage batteries for use in army depots. About a year ago the chief of the construction division of the army requested that the Bureau of Standards should undertake the matter of publishing this manual and that the material which had already been prepared should be revised and added to in order to make the circular of more general use and application. These books can be procured from the superintendent of documents at the Government printing office, Washington, D. C.

The Western Electric Company has arranged with Columbia University for post graduate courses for technical men in its employ, coincident with their regular duties. This system has been limited to the members of the engineering department where more than 3,000 technical students are eligible to take advantage of the offer. Approved graduates of colleges and scientific schools may pursue graduate work for masters' degree and fulfil the requirements in two calendar years. The hours of the work in the engineering department of the Western Electric Company have been especially arranged to provide those who attend the classes at Columbia with full opportunity for study. The salaries of such students are adjusted to the individual circumstances and meet all living and tuition charges. After the candidates are nominated by the officials of their departments they must meet the academic qualifications of the University. Several of the more qualified employees have been permitted to undertake work for a doctorate at Columbia. A special course of training in technical work has also been started by the company to instruct graduates of arts colleges in its engineering methods. A month is set aside by the educational authorities for ground work and after that activity is started in the laboratories. The entire course takes nine months. Outside reading and lectures are required during the period.

A Correction

On page 304 of the August issue of the *Railway Electrical Engineer,* the statement was made that the work of changing two ventilating fans on the C. & O. tunnel at "Big Mound," West Virginia, from steam to electric drive was performed under the direction of J. M. Wilson, manager of the Virginia-Western Power Company. From information later obtained it develops that W. J. Connolly, chief electrician of the C. & O. Railway Company, had the personal supervision of this installation, Mr. Wilson being interested only to the extent of installing the transformer station for the power company from whom the C. & O. Railway purchase electric energy for operating motors.

Telephone Cable for the Swedish Government

The Swedish Government has ordered from the International Western Electric Company a long distance telephone cable to be placed between Stockholm and Göteborg, a distance of about 310 miles. This cable is the latest type used by the American Telephone & Telegraph Company and employs relatively small gauge wires, but it is claimed will provide first-class service, due to its equipment with Pupin loading coils and telephone repeaters. By this means a great number of circuits are provided in a relatively small cable at a cost considerably less than an equivalent number of open wire circuits. This cable is only the first of a large network contemplated by the Swedish Government.

Illuminating Engineering Society's Convention Program

The fourteenth annual convention of the Illuminating Engineering Society will be held at Hotel Statler, Cleveland, Ohio, October 4 to 7. The General Convention Committee of the society has issued the following tentative program:

MONDAY AFTERNOON, OCTOBER 4TH.

President's Address	S. E. Doane.
Report of General Secretary	C. L. Law.
Progress as reported in the Literature of Illuminating Engineering.	Committee on Progress, F. E. Cady, Chairman.
The Society's Educational Program.	Committee on Education, F. C. Caldwell, Chairman.
I. E. S. Headlighting Specifications—Regulatory and Design	Committee on Auto Headlighting Specifications, C. H. Sharp, Chairman.
Survey of Voltage Conditions in Automobile Lighting	H. H. Magdsick. Howard Karg.

TUESDAY MORNING, OCTOBER 5TH.

Modified Views on the Theory of Light	E. F. Nichols.
Some Applications of the Photo-electric Coll	W. E. Story, Jr.
Knowns and Unknowns of Light Production	G. M. J. Mackay.
Optical Principles in Illuminating Engineering	P. S. Nutting.
Measurement of Reflection Factors	G. H. Sharp and W. F. Little.
A Simple Portable Reflectometer of the Absolute Type	A. B. Taylor.

TUESDAY AFTERNOON, OCTOBER 5TH.

Knowns and Unknowns of Illuminating Principles	Auspices Committee on Papers.
Effect of Variations of Intensity of Illumination on Functions of Importance to Working Eye	Ferree and Rand.
Some Uses of the Blue Bulb (Mazda C-2) Lamp for General Illumination	Max Poser.
Notes on Department Store Lighting.	J. Daniels.

TUESDAY EVENING, OCTOBER 5TH.

Pleasing Proportions of Direct and Diffused Light	J. E. Cravath.
*Home Lighting Demonstrations	Nela Park Representatives.

WEDNESDAY MORNING, OCTOBER 6TH.

The Problem of Brightness	Bassett Jones.
Central Station Methods for Securing High Lighting Standards in Stores and Homes	O. R. Hogue. J. J. Kirk and E. D. Tillson.
Some Out-of-the-Ordinary Applications in Mill Work	S. G. Hibben.
An Improved Method for the Illumination of Motion Picture Theatres	L. A. Jones.
Recent Applications of Color in Lighting	A. D. Curtis and J. L. Stair.

WEDNESDAY AFTERNOON, OCTOBER 6TH.

The Society's Work Among Other Organizations	Committee on Reciprocal Relations, Ward Harrison, Chairman.
The High Cost of Poor Lighting	R. E. Simpson.
A New Form of Light Meter	Davis Tuck.
Further Statistics on Street Accidents	Ward Harrison.

THURSDAY MORNING, OCTOBER 7TH.

Central Station Experience in the Improvement of Factory Lighting.	J. B. Wilson.
Lighting of Shoe Factories	A. L. Powell and J. H. Kurlander.
Address of President-elect	G. E. Harries.

---

*Not definitely arranged.

The Coming Convention of the Railway Electrical Engineers

The twelfth annual convention of the Association of Railway Electrical Engineers will be held at the Auditorium Hotel, Chicago, Ill., October 18 to 22, inclusive. The convention meeting proper will start on the morning of Tuesday, October 19, and continue to Friday morning, October 22.

The program as outlined will include reports by the following committees: Committee on Power Trucks and Tractors; Committee on Electric Welding; Committee on Illumination; Committee on Train Lighting Equipment and Practice; Committee on Railroad Stationary Power Plants; Committee on Electric Head Lights; Committee on Electrification; Committee on Electric Repair Shop Facilities and Equipment, and the report of the Auditing Committee.

Copies of the committees' reports, together with the final program, will be mailed so as to be in the hands of the members before leaving their homes for the convention.

The electrical appliance exhibit, which always forms such an interesting convention feature, will be opened Monday evening, October 18. It will be the most complete ever held. In addition to the presentation of the committees' reports, there will be the usual entertainment features.

There is every indication that this year's convention will surpass in importance and attendance any convention that the association has ever held before. Those who are wise will make their hotel reservations early.

Holland Commission Studying Electrification

The commission of railway experts sent by the Government of Netherlands to this country to study American electrification methods has discussed with the engineers of the Westinghouse Electric & Manufacturing Company at East Pittsburgh questions which will involve the selection of equipment for Holland railways. The commission discussed the electrification of railways in general and in particular the Holland railway problems. The commission is studying both alternating current and direct current systems and has made a thorough inspection of the shops in which such locomotives were built.

The president of the commission is L. M. Barnet Lyon, member of the board of control of the Netherland Railways, and J. H. W. Van Loenen Martinet, chief of electric traction of the Netherland Railways, is secretary The other members are H. J. Van Lessen, chief of electrical development of Holland; H. Doyer, consulting engineer, and W. J. Burgersdijh.

It is said that electrification will be started shortly on the railway connecting Amsterdam, the Hague and Rotterdam, which is about 50 miles in length. The equipment will be largely multiple unit, but some locomotives will be used.

PERSONALS

C. D. Axtell, electrical foreman on the Delaware, Lackawanna & Western, with office at Scranton, Pa., has been promoted to superintendent of electrical construction and maintenance, with headquarters at the same place.

L. C. Walters, signal and electrical inspector on the Southern Railway system, with office at Washington, D. C., has been appointed signal and electrical engineer of the Southern Railway, Lines West, with headquarters at Cincinnati, Ohio, succeeding **D. M. Case. T. N. Charles** succeeds Mr. Walters as signal and electrical inspector at Washington.

Lawrence F. Colyer has been appointed electrician, first-class at the West shop of the St. Louis-San Francisco at Springfield, Mo., succeeding **F. P. Burwell,** who has been temporarily transferred to the South shops at the same place. **Sanford Cooper,** electrician, first-class, has been transferred from Sapulpa, Okla., to Monett, Mo., and **W. A. Steele,** electrician, first-class, at the West shop, Springfield, Mo., has been transferred to Sapulpa temporarily, to succeed Mr. Cooper. **Joseph W. Birch,** stock clerk helper at North Springfield, has been made electrician's helper at the South shop at Springfield, Mo., and **Paul W. Lowery** has been made electrician's helper in the traveling wire gang located at Springfield, Mo.

Herbert W. Elfstrom, formerly electrician on the Northern Pacific and also on the Great Northern at Minneapolis, Minn., has entered the employ of the Minneapolis, St. Paul & Sault Ste. Marie as electrician at Duluth, Minn., succeeding **A. M. Adams.** **Nestor Jonas,** electrician's helper in the Willard storage battery service station at Minneapolis, has also entered the employ of this road as electrician's helper at St. Paul, Minn.

Benjamin P. Wallace, formerly wireman with the Howe Electric Company at Sioux Falls, S. D., was recently appointed to the position of electrician, first-class, on the St. Louis & San Francisco Railroad at Enid, Okla. **Jennings B. Miller,** formerly first-class electrician with the Reinsmith Electric Company at Monett, Mo., has been appointed electrician, first-class, with the same road, with headquarters at Monett. Mr. Miller succeeds **E. D. Parker,** deceased.

Allen B. Coffman, assistant electrical engineer of the Philadelphia & Reading, with headquarters at Reading, Pa., resigned from that position on August 15, to enter the sales department of the Crouse-Hinds Company, Syracuse, N. Y., where he will handle railway and marine sales in the south. Mr. Coffman was formerly with the Pennsylvania Railroad on the mountain electrification work, with headquarters at Altoona, and in July, 1916, went with the Philadelphia & Reading.

Major Phillip Dawson has received the honor of knighthood at the hand of King George. Sir Phillip is a partner of the firm of Kincaid, Waller, Manville & Dawson, consulting engineers, London. He is also consulting electrical engineer of the London, Brighton & South Coast Railway. In the early days Dawson's "Electric Traction" was the standard book on electric railway engineering, and later his handbook was recognized as the authority on that subject. During the war Sir Phillip rendered valuable service as a member of the Disposal Board, Ministry of Munitions. He was also named a member of the commission appointed by the Belgian Government to investigate the future of the Belgian State Railways. He is now prominently associated with the scheme for the electrification of these railways. Sir Phillip is a member of the Institute of Civil Engineers, the Royal Institute of Mechanical Engineers and the Institute of Electrical Engineers.

TRADE PUBLICATIONS

The Copper Clad Steel Company, New York, N. Y., is distributing an attractive little envelope folder illustrated in colors, describing the uses of "Copperweld" for aerial cables. The folder briefly states why this product is economical for wireless purposes.

Bearings and Their Lubrication is one of the many educational papers published by the Vacuum Oil Company, New York. The book has been prepared by the technical department of the Vacuum Oil Company and it is expected that it will be used extensively as a textbook by many colleges and technical schools throughout the United States.

Roller-Smith Company, New York, N. Y., is distributing an 8-page illustrated envelope pamphlet showing its portable d. c. ammeters, a switchboard type d. c. voltmeter, its a. c. and d. c. wattmeters for switchboard use and a single and three-pole circuit breaker.

Appleton Electric Company, Chicago, Ill., have just issued bulletin No. 14, consisting of eight pages in which will be found listed a complete line of solid and sectional switch boxes with bevel and square corners, furnished for loom and flexible conduit, also ½ inch and ¾ inch rigid conduit. Copies will be sent on request.

The Sangamo Electric Company, Springfield, Ill., recently published its bulletin No. 54, giving complete instructions for Sangamo type D-5 Watthour Meters. The pamphlet consists of 20 pages and measures 8 in. by 10½ in. It is comprehensively illustrated with numerous photographs and line drawings, showing the connection to various electrical circuits.

Crouse-Hinds Company, Syracuse, N. Y., have just issued a new bulletin on condulets for steam and electric railroads. The bulletin contains 48 pages showing condulets of the latest designs for car wiring, locomotive wiring, signal tower battery charging, locomotive and car shop wiring, and for many other purposes. This bulletin is useful in that it contains so many illustrations and extensive descriptive matter of condulets for railroad work.

The Electric Service Supplies Company, Philadelphia, Pa., is distributing its bulletin No. 166, in which are illustrated and described numerous details of the Keystone Locomotive Headlight Equipment. The booklet contains 48 pages, 6 in. by 9 in. in size and an abundance of illustrations faithfully portraying all of the various parts of this equipment. Among the apparatus listed are Keystone Turbo-Generators, Golden Glow Locomotive Headlights, Keystone Headlight Switches and Keystone Classification and Tender Lights.

The National Carbon Company of Cleveland, Ohio, has released to the trade its new motor and generator brush catalogue No. 35, in which the line of Columbia Pyramid Carbon Brushes is described and illustrated. The catalogue is designed to assist the operator as well as the engineer toward a better understanding of brushes, and in preparing it the problems of manufacturers, designers and operators have been borne in mind. If further information on any particular grade is desired, the engineering department of the National Carbon Company will be glad to supply it.

The National Lamp Works of the General Electric Company, Cleveland, Ohio, has issued eight bulletins on the general subject of illumination engineering. The bulletin numbers and the subjects covered are as follows: 7C, Fundamentals of Illumination Design, 66 pages; 10D, Essentials of Train Lighting, 16 pages; 20A, Industrial Lighting, 96 pages; 32, Light Projection and Its Applications, 50 pages; 35, The Lighting of Offices and Drafting Rooms, 96 pages; 36, Lighting Comment, 57 pages; 39, A Turning Point in the Lighting Industry, 14 pages; 40, Maintenance of Lighting Systems, 15 pages. The bulletins are prepared for the most part by the engineers of the General Electric Company and are well worth the attention of anyone interested in lighting.

Railway Electrical Engineer

Volume 11 October, 1920 Number 10

COMMITTEE REPORTS

The issue of the *Railway Electrical Engineer,* which you now hold in your hands, contains the complete reports of all of the committees that have been assigned subjects for presentation at the twelfth annual convention of the Association of Railway Electrical Engineers. That we have been able to get these reports to you in time for your careful perusal before starting for the convention is due in a very large measure to the promptness with which the several committees turned in their reports.

In going over this year's reports there are two factors which stand out prominently. One of these is the comparative brevity of the reports and the second is that there are fewer of them. This does not mean that the subjects have been slighted nor that there was a dearth of subjects when the committees were appointed. The fact that the reports show a tendency to be shorter than those presented at previous conventions should prove to be one of the most valuable assets of the convention, for it is obvious that the less time consumed in presenting any particular report, the greater the time will be for the discussion on the part of the members. There seems to tion. If there is one thing more than another that is needed to make any convention a real success it is a live discussion on the part of the members. There seems to be in almost every convention an overwhelming tendency to "let George do it," and usually there are a sufficient number of Georges on hand to carry on that which passes as discussion. However, it is safe to say that there is not a single person who is sufficiently interested to read these reports and to attend the convention but who will not have some really valuable ideas concerning the subjects, which are not included in the reports. If each member attending the meeting would only make it a point to contribute his little, what a wonderful success a convention might be made.

It seems almost unfair to single out from the other reports any particular one for laudatory purposes, for each report covers its subject in such a clear and concise manner. However, in view of the widespread interest in the subject of heavy electric traction we feel that the committee to whom this subject was assigned should be complimented especially in gathering together much needed data that is specific and not general in character.

It is also pleasing to note the new subjects which have been added to this year's program, namely, the report of the Committee on Electric Repair Shop Facilities and Equipment, and the report of the Committee on Power Trucks and Tractors. The necessity for good repair shop facilities cannot be overestimated. Trucks and tractors no doubt have received a stimulus due to the present shortage of labor and the urgent need of moving freight quickly at terminals and transfers and making the most out of existing shop facilities. There is every reason to believe that their use will continue to expand wherever material has to be handled, and that they will be eventually adopted solely for their efficiency, regardless of labor conditions.

In general, therefore, it would seem that the several committees of the association, this year, are dealing with the most vital subjects and the interest of every member should be centered in a live discussion of these important topics. Come to the convention prepared not merely to sit and listen, but prepared to get up and say something, yourself.

RAILROADS MAKING GOOD

The general railroad situation has improved greatly during recent weeks. Local congestions have been cleared up by the judicious use of embargoes through the efforts of the local car service committees and by improvements in operation. Accumulations of freight cars on hand in excess of current movement, for instance, had been reduced to less than 48,000 for the week ending September 17. Last April there was an accumulation of almost 300,000 delayed cars. During times of heavy traffic an accumulation of 30,000 cars or more is regarded as normal. The number of freight car loadings per week has been approaching the 1,000,000 mark and generally speaking, has been exceeding the loadings for comparative weeks for preceding years.

This result has been made possible through good teamwork on the part of the railroad forces and by co-operation on the part of the shippers. There is much grain and coal still to be moved and it will be necessary to get still better work out of the transportation machine during the fall months. It is interesting to know that in July, the latest month for which the figures are available, 12 of the large roads exceeded the goal of the railroad executives for an average loading of 30 tons per freight car; 15 large roads had attained an average movement of over 30 miles per car per day. Doubtless a number of other roads reached the goal during the months of August and September.

Unfortunately only a very small amount of new freight car equipment has been built during the year. Many of the older cars should have been retired a long time ago, or else rebuilt and reinforced. It is poor economy to attempt to run these cars under present conditions, for they are causing frequent wrecks, resulting in considerable damage to the lading as well as to the better-class cars.

It is too early to gain any adequate idea of the effect of the increased rates, but it is expected that the financial returns will not be disappointing, particularly since the roads have been handling a maximum amount of traffic. Unfortunately some of the state commissions are refusing to allow intrastate rates to be raised to the standards established by the Interstate Commerce Commission. This means not only a considerable direct loss in revenue, but also a large indirect loss due to the confusion caused by having different rates in effect for intrastate and interstate traffic.

While the roads are still facing a crisis, it may be said, on the whole, that a remarkable improvement has been made in operation but that this can be still further improved by loyal co-operation on the part of all of the employees.

WHY USE THE METRIC SYSTEM?

From time to time the question arises from one source or another, why is it that the metric system is not more generally adopted in this country? A very large number of reasons could be presented showing why this system of weights and measurements has not met with favor. Most of those who oppose the system have excellent, practical, manufacturing reasons, but in addition to all of these there is one reason that is so intensely human that it might well be looked upon as fundamental. The metric system has not been, nor ever will be, adopted in any English-speaking country for exactly the same reason that the people of such countries would not universally adopt a foreign language in place of their own. In order to derive any benefit from the use of the metric system, one must be able to think clearly and quickly in its terms without having to hesitate in order to translate its meaning into English units. This is the fundamental reason why the metric system has not been adopted in English-speaking communities.

STEAM vs. ELECTRIC LOCOMOTIVES

Announcement is made in the news section of this issue of a joint meeting of the New York Section of the American Institute of Electrical Engineers, the Metropolitan Section of the American Society of Mechanical Engineers and the Railroad Section of the A. S. M. E., to be held on October 22, in the Engineering Societies building, 29 West 39th street, New York. The relative advantages of modern steam and electric locomotives will be outlined by four able speakers and discussed by others who are well acquainted with steam and electric equipment. This program will undoubtedly attract much attention. The subject of electrification has grown in general interest until it has been made a part of the proceedings of societies not originally interested in anything pertaining to railroads. A large amount of good material has been prepared on the subject but it has lacked in cohesion and specific facts and has been tempered by manufacturers lauding their favorite type of equipment. The relative merits of alternating and direct current apparatus has long been a bone of contention. This time the electrical manufacturers will probably be obliged to get together and the meeting will bear the official stamp of two of our best engineering societies. The Railroad Section of the A. S. M. E. is to be commended for arranging a meeting which should be one step toward the crystallizing of a mass of unassimilated claims and data. Such meetings as these, together with the investigations made by committees appointed by railroads, and such work as is being done by the electrification committee of the Association of Railway Electrical Engineers, are essential to the cause of electrification. Such work is the only means for clearing up uncertainty in the minds of prospective users and it will put electric traction on the sound basis on which it belongs.

EMERGENCY USES FOR HEADLIGHT GENERATOR

While no one will dispute that the headlight turbo-generator is designed primarily for the use which its name implies, it is nevertheless conceivable that emergency uses might easily arise for it which might never have been dreamed of when the equipment was designed. On page 338 of the *Railway Electrical Engineer* for September a very brief sketch was printed showing the utility of headlight equipment in a wreck emergency. Suggestions have also been made in the past that the turbo-generator might be used as a source of power for wireless telegraphy where smaller units were required and where steam pressure for its operation was available. The fact that alternating current headlight equipments have been placed on the market may possibly open up some auxiliary uses which have not heretofore been thought of. It will certainly be surprising if numerous other uses for headlight generators are not found in view of the many thousand of these equipments which have been installed on the locomotives in this country.

MATERIAL HANDLING MACHINERY

The scarcity of labor and the necessity, if the prosperity of the country is to go forward, of placing at the hands of the workmen some means of conserving their strength and multiplying their output, has focused attention on the vital necessity of introducing material handling machinery in different departments of railroad service. The fact must not be lost sight of that in order to increase the average mileage of freight cars to 30 miles per day, it will be necessary to very greatly improve the loading, unloading and handling facilities at freight houses, terminals and industrial and commercial plants. The electrical engineer is vitally concerned with this development because such a large part of this machinery is operated by electrical power. Some of these material handling devices can be introduced quickly, while others will come slower because it will be necessary to considerably rearrange or remodel the facilities in order to introduce them. These latter, however, because they are so vital to improved efficiency of operation, will come near the head of the list of the permanent improvements that will have to be made just as soon as the credit of the railroads can be restored. The railway electrical engineer will do well to study these developments closely, in order that he may be prepared to give proper attention to the electrical features when the new machinery or devices are installed.

Association of Railway Electrical Engineers Twelfth Annual Convention

October 19-22, Chicago

CONVENTION PROGRAM

Meetings to Be Held on Ninth Floor, Auditorium Hotel Exhibits in Ball Room on Same Floor

Tuesday, October 19

Session, 10:00 a. m to 1:30 p. m.
Address of President.
Report of Secretary-Treasurer.
Report of Auditing Committee.
Unfinished Business. New Business.
Committee on Illumination (page 371).

Wednesday, October 20

Session, 9:30 a. m. to 1:30 p. m.
9:30 a. m. to 10:30 a. m.—Committee on Heavy Electric Traction (page 360).
10:30 a. m. to 12:00 m.—Committee on Electric Headlights (page 347).
12:00 m. to 1:30 p. m.—Committee on Railroad Stationary Power Plants (page 355).

Thursday, October 21

Session, 9:30 a. m to 1:30 p. m.
9:30 a. m. to 10:30 a. m.—Committee on Electric Welding (page 372).
10:30 a. m. to 12:00 m.—Committee on Train Lighting (page 361).
12:00 m. to 1:30 p. m.—Committee on Electric Repair Shop Facilities (page 349).

Friday, October 22

Session, 9:30 a. m. to 1:30 p. m.
9:30 a. m. to 10:30 a. m.—Committee on Power Trucks and Tractors (page 353).
10:30 a. m.—Election of Officers.
Afternoons will be devoted to inspection and study of electrical appliances in exhibit room.

Registration

Please register and secure badges at Secretary's desk, located south of elevator in exhibit room on the ninth floor.

Theatre and dinner tickets should be reserved at the time of registration.

Entertainment

Tuesday evening, October 19, 8:30 p. m. Informal reception and dancing party, ninth floor, Auditorium Hotel. Refreshments will be served. Admission by badges.

Ladies' theatre party has been arranged for Wednesday afternoon and ladies' automobile party for Thursday.

Informal dances will be held on other evenings. Inquire at Secretary's desk for full particulars.

Report of Committee on Locomotive Headlights

Tests Show Considerable Variation With Different Reflectors Under Different Atmospheric Conditions

Committee

E. W. Jansen (chairman), electrical engineer, Illinois Central.
L. C. Hensel, electrical engineer, St. Louis & San Francisco.
George E. Murray, electrical and mechanical engineer, Grand Trunk.
Charles R. Sugg, electrical engineer, Atlantic Coast Line.
J. A. Andreucetti, assistant electrical engineer, Chicago & North Western.
J. L. Minick, assistant engineer, motive power department, Pennsylvania Lines.
F. J. Hill, chief electrician, Michigan Central.
H. R. Pennington, supervisor of welding and electrical equipment, Chicago, Rock Island & Pacific.
George B. Colgrove, chief electrician, Illinois Central.
F. C. Watson, chief electrician, Chesapeake & Ohio.
L. C. Muelheim, chief headlight supervisor, Baltimore & Ohio.

SINCE the Atlantic City Convention in June your committee has continued to pursue the study of the headlight subject and has been able to hold one meeting between that time and the present. At that meeting the past work of the committee was gone over, its previous reports were reviewed and a number of new matters presented, which are herewith recommended for affirmative action at this convention.

Tests on Headlights for Locomotives in Yard Service

In view of the importance of the matter concerning a satisfactory headlight for locomotives in yard service, it was hoped that a report on the results of certain tests would be available for the consideration of this committee, but it was learned that the tests were still in progress at the time of your committee's meeting. These tests, in which wide interest was manifested were conducted by the National Lamp Works at Nela Park, Cleveland, Ohio, for the purpose of obtaining much needed data on this subject. The desire also was to secure some comparative results on various types of reflectors. Owing to the extensive scope of the tests, therefore, it will be some time, no doubt, before the complete official report is ready. However, it may be available in time for discussion at this convention. In any event it is understood that when the data is fully compiled in report form copies will be available for the general information and benefit of the various railroads.

Several of the members of the committee were present during a portion of what might be considered the more important features of the test and memoranda taken at that time showed general average results as follows:

Three different makes of standard 18 in. by 9 in. silvered copper reflector with 250-watt headlight lamp:

Equipment.	Pick-up Distance.
No. 1	935 ft.
No. 2	971 ft.
No. 3	1,014 ft.

Two different makes of 14-in. glass reflector with 250-watt headlight lamp:

No. 1	1,006 ft.
No. 2	1,080 ft.
18 in. by 9 in. silvered copper reflector, *tarnished,* with 250-watt headlight lamp	750 ft.
18 in. by 9 in. silvered copper reflector, No. 1, with 100-watt headlight lamp and *diffusing lens*	748 ft.
Same as above with 60-watt headlight lamp	1,019 ft.*

*This distance being greater than that obtained with the 100-watt lamp was probably due to the more closely concentrated filament of the smaller lamp.

While the distances obtained with the diffusing lens were relatively great, affording a substantial factor of safety for the requirement of headlights in yard engine service, a widespread of the beam was produced with a notable absence of glare. Beam candle power readings were taken in the more important pick-up tests and, when the complete report is available, it will no doubt be of great interest and value to analyze these readings as indicating the approximate light value required to meet the headlight law.

A series of headlight tests were also conducted by the Philadelphia & Reading Railroad during the night of July 14, 1920, near Reading, Pa., and through the courtesy of I. A. Seiders, superintendent motive power and rolling equipment, your committee has been favored with a report on the results of this test. The purpose of the test, it is understood, was to observe the performance of certain glass reflectors as compared with the standard 18 in. by 9 in. silvered copper reflectors, and to observe the results of deterioration of certain other silvered copper reflectors which had been in service for varying periods of time without being cleaned. It was also arranged to vary the height of the headlight in the tests to conform to the different heights of headlights on their various classes of locomotives. Following is a summary of the report with comments made:

Test No.	Equipment	Height of headlight	Rated voltage	Voltage at lamp	Weather	Readings 1st	Readings 2nd	Readings 3rd
1.	Standard 18-in. silvered copper reflector. New	9 ft. 10 in.	32	32	Cloudy	775 ft.	750 ft.	700 ft.
2.	14-in. Crystal glass reflector	9 ft. 10 in.	32	32	Clear	1,300 ft.	......	......
3.	14-in. Crystal glass reflector	9 ft. 10 in.	32	32	Clear	950 ft.	1,150 ft.	......
4.	14-in. (1919) Golden Glow glass reflector. Old	9 ft. 10 in.	32	30.75	Clear	1,200 ft.	......	......
5.	14-in. (1920) Golden Glow glass reflector. New	9 ft. 10 in.	32	32	Clear	1,150 ft.	950 ft.	......
6.	18-in. silvered copper reflector. New	9 ft. 10 in.	32	32	Clear	1,150 ft.	1,000 ft.	......
7.	18-in. silvered copper reflector	12 ft. 10 in.	30	30	Slight fog	900 ft.	......	......
7-A.	Same as next above with lamp rated at 32 volts	12 ft. 10 in.	32	32	Slight fog	1,000 ft.	......	......
8.	18-in. silvered copper reflector, tarnished, in service 14 months	12 ft. 10 in.	30	30	Slight fog	550 ft.	......	......
9.	Same reflector as next above, cleaned, same lamp	12 ft. 10 in.	30	30	Slight fog	1,050 ft.	......	......
10.	18-in. silvered copper reflector, tarnished, in service 19 months	12 ft. 10 in.	30	30	Slight fog	450 ft.	......	......
11.	14-in. Crystal glass reflector	12 ft. 10 in.	30	30.5	Clear	900 ft.	......	......
11-A.	Same reflector as next above with lamp rated at 32 volts	12 ft. 10 in.	32	32	Clear	900 ft.	......	......
12.	14-in. Crystal glass reflector	12 ft. 10 in.	30	30	Clear	900 ft.	......	......
12-A.	Same reflector as next above with lamp rated at 32 volts	12 ft. 10 in.	32	32	Clear	1,200 ft.	......	......
13.	14-in. (1920) Golden Glow glass reflector. New	12 ft. 10 in.	30	30	Slight fog	950 ft.	......	......
13-A.	Same reflector as next above with lamp rated at 32 volts	12 ft. 10 in.	32	32	Slight fog	950 ft.	......	......
14.	P&R switching service headlight and converted reflector with number slots, reflector well polished	12 ft. 10 in.	30	30	....	550 ft.	......	......

NOTE.—Lamp used was standard Westinghouse 250 watt, 32 volt, G-30 bulb, concentrated filament headlight lamp, calibrated, and delivered 4,500 lumens.

"It was particularly noted that the glass reflectors in all probability could be more easily kept clean and meet the requirements of the law.

"The Crystal glass reflectors seemed to be more bright and penetrating, and in all probability would cause considerable comment from the engineers on account of being too bright.

"The Golden Glow glass reflectors seemed to have a very penetrating ray, but it seemed to be somewhat of a softer light and did not hurt the eyes as much as the Crystal glass reflector.

"It was also noted that when the headlight was located at a point equivalent to the location on the front of the smokebox door, at a height of 9 ft. 10 in., the object was seen a greater distance than when placed at a height of 12 ft. 10 in., or above the smokebox door. It is felt, however, that more damage will be done to the headlight in the former location through the frequent opening of the door, and since the headlight at the higher location exceeds 800 ft. it is believed this location should be adopted.

"It was further noted that particular attention had to be given the matter of focusing in order to obtain the most satisfactory light and the greatest pick-up distance, showing clearly the importance of the proper focusing of the headlight lamp."

At both the above series of tests the 14-in. glass reflectors appeared to demonstrate their ability to safely meet the I. C. C. headlight requirements, while the colored glass type won specially favorable comment as a result of the soft character of the beam they produce and the less blinding and fatiguing effect on the eyes of those looking directly at the headlight as compared with the silvered copper reflector. With regard to the yard locomotive headlight, however, it is hoped the formal report of the Cleveland tests will indicate a practical solution of the present problem of eliminating the objectionable glare, at the same time satisfactorily meeting the demand of the law.

Signal Lamps on Locomotives

In the matter of signal lamps on locomotives, and in order that this subject be fully developed, it is recommended that the paragraph in the committee's report submitted at the June semi-annual convention recommending agreement on the adoption of a combination classification and marker lamp, be stricken out. Instead, it is recommended that the secretary of this association be authorized to communicate with the secretary of the American Railroad Association requesting that arrangements be made for a joint meeting of this committee with the Headlight and Train Rules Committees of the A. R. A. for the purpose of developing, if possible, the most satisfactory practice in connection with this important matter.

It is suggested the joint meeting be held at New York or Chicago, or where most suitable, and that the following questions be presented for discussion; the reasons for the questions also following:

Question A.—May classification and marker lamps be permanently attached to the locomotive and tender?

Reason A.—On account of the loss of signal lights due to shaking loose from vibration, and the consequent danger of putting the entire headlight equipment out of service from the breaking or short-circuiting of the wires, there is a disposition on the part of some railroads to attach these lights permanently. If so attached will the practice conflict with existing train rules?

Question B.—Define the difference between classification and marker lamps.

Reason B.—There is considerable confusion as to the purpose or function of these two types of lights and a disposition on the part of some of the railroads to combine them.

Question C.—How and where should the classification and marker lights be located or mounted?

Reason C.—The present train rules indicate that these lights shall be mounted so as to be visible from the locomotive cab, whereas the present actual practice is to so mount them as to make them invisible from this position.

Question D.—Should classification and marker lamps have two, three or four lenses?

Reason D.—Owing to the change in the manner of lighting, from oil to electric, different classification and marker light equipment must be designed for the electric service, which prompts the question as to whether this equipment should have four lenses, as now required by the train rules, or may it have a lesser number such as now being used by some of the railroads?

Question E.—What size lens should be used?

Reason E.—It is the understanding of this committee that one of the A. R. A. committees has recommended the use of a 7-in. diameter lens for all signal lights, whereas the present practice is to use a 5-in. diameter lens.

Question F.—Should the classification and marker lights be controlled at the lamps or by a switch in the locomotive cab?

Reason F.—This committee has considered it, and experience has demonstrated it to be decidedly bad practice to control these lights from the locomotive cab.

Question G.—Does not the introduction of electric lighting on steam locomotives bring about a condition which makes it advisable and necessary to revise the present train operating rules insofar as these rules affect the locomotive signal lamps?

Reason G.—Indicated in the foregoing items.

Bolt and Screw Threads for Electric Headlight Equipment

In the matter of bolt and screw threads, it is recommended that such arrangements as may be necessary be made through the secretary of this association as will enable this committee, jointly with the A. R. A. Headlight Committee, to take up with the International Committee on bolt and screw threads, with a view to standardization of these threads for electric headlight equipment. This is in line with this committee's recommendation that the so-called A. S. M. E. thread be standardized for this equipment and that machine screw threads (A. S. M. E. standard) be adopted for sizes smaller than ¼ in. diameter and bolt threads (A. S. M. E. standard) for ¼ in. diameter and larger.

Committee Recommendations

In order to develop certain other features which are of considerable importance in connection with the headlight subject, your committee recommends the following:

1.—On locomotives having pressed steel front ends the headlight should not be mounted on the front of the smokebox door, on account of the vibration caused by the pulsating action of the locomotive exhaust, and also on account of the difficulty of towermen seeing the locomotive number in the headlight case where such locomotives operate in multiple track service. That the headlight be mounted as high as practicable on the front end above the smokebox door.

2.—That this committee in joint meeting with the A. R. A. Headlight Committee give consideration to the matter of improvement of the signal lamp supporting socket or bracket in order to overcome the trouble of the lamps jolting out of these supports and breaking the electrical connection with the resulting failure.

3.—That a joint sub-committee, made up of the A. R. E. E. and A. R. A. Headlight Committees, be appointed to prepare and submit for recommendation a design, or designs, of a standard headlight case.

Regarding the matter of a standard design of plug and receptacle for detachable signal lamps, recommended in the committee's June, 1920 report, it is now recommended that the paragraph in that report be stricken out and this matter held open until the general question of the signal lamps can be properly developed.

It is also the sense of the committee that its former recommendation concerning the ¾ in. steam supply and turbine drain pipes should be modified so as to recommend a ¾ in. steam line with not less than ½ in. inlet direct to the turbine, and a ¾ in. pipe for the entire drain pipe.

In order to eliminate reference to trade names in connection with the committee's recommendation regarding "condulet fittings," it is felt the term "conduit fittings" should be substituted for the present "condulet fittings."

As the various railroads have now had more or less experience with oil and grease for lubrication of the turbo-generator set, it is recommended that, on the basis of such experience as has been gained, the relative merits of the two types of lubricant be discussed at the convention, as it will be recalled the previous recommendation of the committee was to the effect that the headlight manufacturers design their equipment so as to accommodate either type of lubricant.

Another matter upon which a general discussion would no doubt be beneficial is the difference that is apparent between a prepared, standing headlight test and a test made while the locomotive is running, or under actual operating conditions. Discussion of this matter by the committee resulted in its belief that an object can be seen under regular running conditions only approximately 60 per cent of the distance possible under prepared standing test conditions. It is felt, therefore, that the headlight, to fully meet the requirements, should enable the observer to distinguish an object at approximately a 40 per cent greater distance when standing than while running.

The pick-up distance method of rating the efficiency of the headlight is generally considered unsatisfactory, and in view of this association's disapproval of this standard of rating, which method involves a more or less indefinite element, it is recommended that the matter be further taken up by the association in an effort to have this standard of rating changed to a "Beam Candle Power" basis, as this method of rating affords a definitely measurable process.

It is further recommended that this report be received and the committee continued.

Report on Electric Repair Shop Facilities and Equipment

The Recommendations Made Cover the Layout and Equipment Required for Various Classes of Shops

Committee

E. H. Hagensick (chairman), electrical engineer, Union Pacific.

Geo. E. Murray, electrical and mechanical engineer, Grand Trunk.

Jos. A. Andreucetti, assistant electrical engineer, Chicago & North Western.

W. J. Connolly, chief electrician, Chesapeake & Ohio.

E. S. M. MacNab, car lighting engineer, Canadian Pacific.

Geo. Dodds, electrical engineer, Delaware & Hudson.

YOUR committee was instructed to report on the question of proper layout for electric repair shops at railway shops. Several meetings of the committee were held and a progress report was submitted at the semi-annual meeting in June, at which meeting the discussion of certain features was invited and members were requested to forward to the chairman a description of any specially desirable features of their own shops which they considered might be of value to the rest of the membership.

The question of assigning sufficient space and providing proper shop facilities for the electrical repair department is one which has been given very little consideration in most railway shops. It is the thought of your committee in this connection to submit an actual layout of a well-planned electrical repair shop, which, in its opinion, is an ideal arrangement and one which does not exist on most railroads. Your committee feels that if the subject of shop facilities for the electrical department is properly brought to the attention of those officials responsible for these matters, a great deal of improvement can be accomplished; and the layout submitted with this report will serve as a guide, and help them to arrive at a conclusion as to the proper shop layout.

The Requirements and Location of Electrical Repair Shop

The electrical repair shop should have proper facilities for taking care of all motor and armature repairs, coil winding, headlight turbine and generator repairs, as well as incidental electrical repairs necessary about a railroad shop, such as controller repairs, extension cords, etc. In a large shop, composed of a number of buildings and covering considerable ground area, the location of the electrical repair shop is quite important, because of the fact that the electricians working out of this shop are required to go to all buildings, and the location should be as nearly central as possible. However, the amount of electrical installation in the various buildings should be taken into consideration in making this selection.

In a modern railroad shop in which a large number of the machines are motor driven a large percentage of the total number of motors will be in the machine shop, and headlight work on engines undergoing repairs can be most conveniently carried on in this shop. For this reason the committee recommends a space for the electrical repair shop in this building.

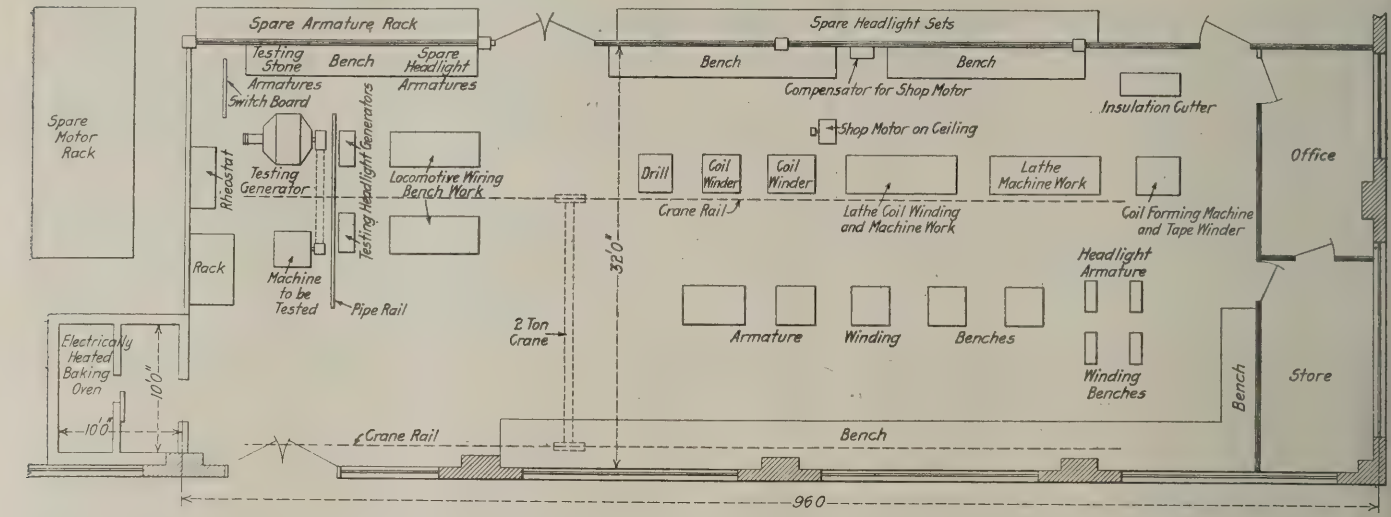


Fig. 1—Plan of Electrical Repair Shop Layout Showing Facilities and Location of Equipment Used

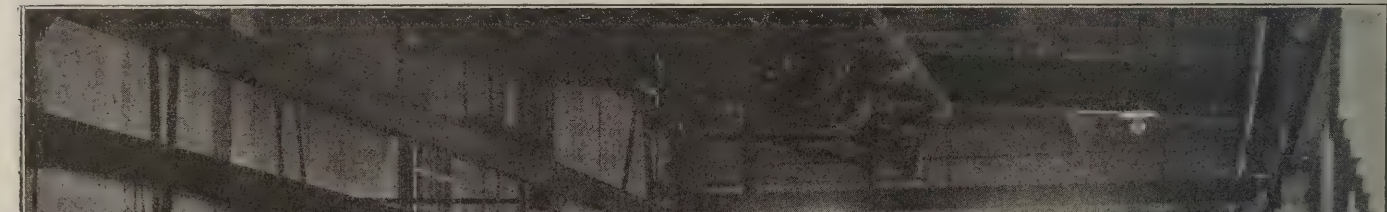


Fig. 2—The Electrical Repair Shop Looking Toward the Office End.

If the machine shop is provided with a balcony, location there would be suitable, but, regardless of where located, the committee recommends that the space assigned for the electrical repair shop be separated from the rest of the shop, preferably by a wall, or, if this is not feasible, the space provided should at least be enclosed by a fence. It is desirable to have the entire electrical shop served by a traveling crane. This service may be provided by the traveling shop crane, but if the location of the shop is on a balcony or in a bay which is not served by one of these cranes, a hand operated traveling crane of about two tons capacity should be installed.

An Electrical Repair Shop of a Large Railroad

The plan, Fig. 1, shows the arrangement of the repair shop of a large railroad which takes care of the electrical maintenance of the shop. The committee recommends that the general arrangement of this shop be followed as a guide, making such alterations as are necessary to meet local conditions. The photographic reproductions, Figs. 2 and 3, are pictures of the same shop. These illustrate the arrangement of the facilities in use and the type of work carried on in various sections of the shop.

The plan, Fig. 1, definitely assigns a space for a store room and it is the recommendation of the committee that the supply of those parts used only for motor repairs be carried in a sub-store at the electrical shop rather than in the general store room. By so doing, the foreman of the shop will know at all times what material is on hand, on order and in the shop being made up, and he can be made responsible for keeping a well balanced stock. By this arrangement a great deal of time will be saved that would otherwise be necessarily spent going to and from the general store for material, and a considerable saving in material should be effected, as practically exact amounts needed would be used and could be accurately charged to the various jobs. The electrical sub-store should be under the supervision of the foreman but directly in charge of his clerk, who would be on duty continuously in the office adjacent to the store room during working hours. The store room should, of course, be under lock and key and no entrance into the shop allowed except for delivery of material, regular entrance being through the office, which, as stated before, should be adjacent to the store room. Ample space should be provided in the office to take care of the necessary desks, filing cabinets and regular office equipment as well as a roomy cabinet for taking care of all portable instruments.

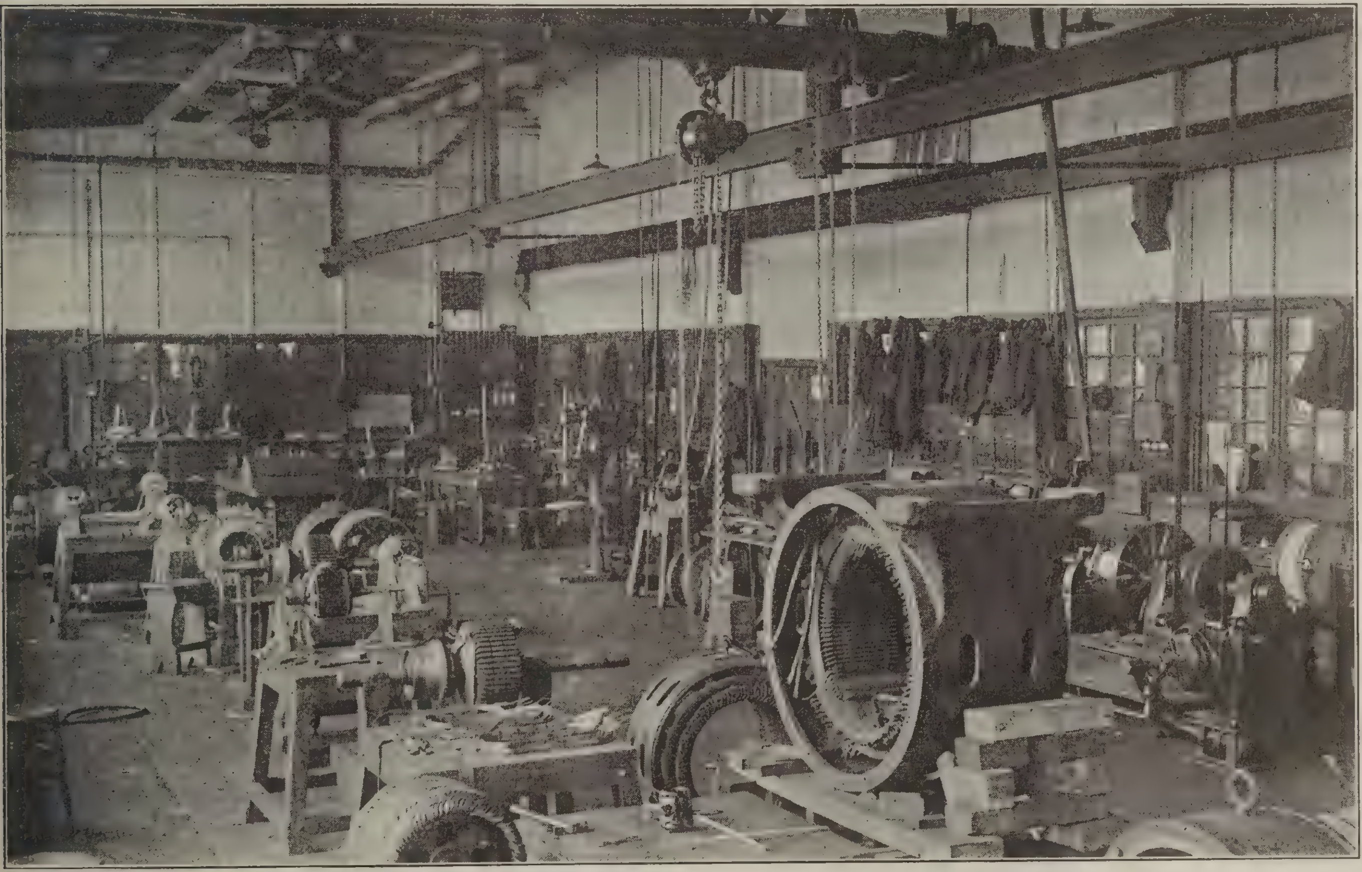


Fig. 3—The Electrical Repair Shop Looking Toward the Testing Floor End

Storage Racks and Other Fixtures

Suitable storage racks should be provided in the main shop for incoming equipment to be repaired as well as finished work. This applies particularly to armatures and motors. The racks shown in Figs. 4 and 5 will nicely take care of d. c. armatures and a. c. rotors.

A low heavy table is desirable on which defective motors can be placed, thereby raising them above the floor level so that the workmen can more readily inspect and test them. Power circuits should be convenient to this table for all voltages used in the shop or division of the railroad for which this shop makes motor repairs. The table should be sufficiently large to accommodate easily the various testing instruments used in diagnosing the trouble. After it has been decided what part of the motor is in need of repair, it can be torn down on the testing bench. The part in need of repair should then be placed in a box where all dirt can be blown from it by compressed air. This box should be provided with an exhaust blower so that dust and dirt will be taken away and deposited at some convenient point.

Ample bench room should be provided along the wall under the outside windows, and at each vise there should be a drawer for taking care of mechanics' tools, a gas and air connection, also a test lamp in the lighting circuit with permanent portable points to be used for general testing.

Winding racks for handling armatures and rotors undergoing repairs are necessary. These should be designed to take care of any length of armature to be handled and preferably one head should be adjustable in order to cut down the total number of racks required.

Dipping and Baking Armatures

There is some difference of opinion as to whether or not it is desirable to dip and bake an armature after it has been repaired. This is a question which each must decide for himself. If it is decided that dipping and baking is desirable the armature should first be dried in an oven for 10 hrs. at a temperature of 100 degrees C., the commutator and bright metal parts should then be taped with friction tape and the armature immersed and allowed to soak in the insulating material until all signs of bubbling cease, which will be at the end of about 20 or 30 min. When bubbling ceases it indicates that practically all of the air and moisture has been driven out of the windings and it should then be placed in a carrier on wheels in such a manner that the shaft will be perpendicular and immediately placed in the oven, where it should remain until the varnish is dried and hard. The temperature of the oven should remain at not less than 100 degrees C. By standing the armature on end the excess compound will drain out in such a way as to not throw the armature out of balance, as would be the case if it were laid on its side.

The committee recommends that the impregnating tank be sufficiently large to completely immerse the largest armatures, and that a suitable cover be provided to cover the tank when not in use. The oven should be amply large to handle a number of the largest armatures at one time and doors should be provided so the armature carrier can be wheeled in.

Machines, Coil Winding and Testing Appliances

Other equipment that should be furnished in the shop includes a small lathe, drill press, foot-power squaring shear, coil winding machine, tapping machine or tapping attachment, commutator slotting machine, as well as a rack for storage of conduit from engines undergoing repairs in the shop, a pipe bench and vise, bench for repairing and testing head-light turbines, and shelving for miscellaneous material coming into the shop for repairs.

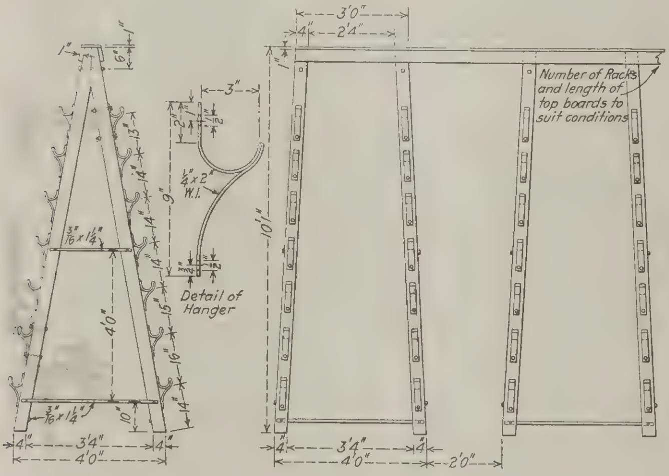


Fig. 4—Storage Rack for Repaired Armatures

For railroads located a considerable distance from the large electrical manufacturing concerns, we recommend the winding of all armature field and stator coils; since with a good winding machine these coils can be very quickly assembled by a first-class workman, and by following this arrangement a large reduction can be made in the amount of store stock. If the attempt is made to carry coils for the various types of motors a large stock is necessary, whereas, when coils are made up as needed, because of the fact that a great number of these coils are wound with the same size wire, it is only necessary to carry a comparatively small amount to take care of repairs. For example, consider three motors using the same size of wire in the coils:

	Amount of wire	No. of coils
Motor No. 1....................	75 lbs.	50
Motor No. 2....................	60 lbs.	40
Motor No. 3....................	90 lbs.	60
	225 lbs.	150

In order to have a sufficient number of coils available to completely rewind any one of these motors it would be necessary to carry in the store 150 coils or approximately 225 lbs. of wire. If coils are wound as needed a supply af 100 lbs. of wire would be ample stock to carry, as this amount would be sufficient to make up a complete set of coils for any one of the motors. Obviously if this practice is extended a large saving will result.

The committee recommends in connection with any repair shop a liberal supply of portable ammeters and voltmeters for all the voltages in use. It also feels that a megger is a desirable addition to the equipment of such a shop. By making regular insulation tests of motors in service with this instrument a great many motor defects can be detected and corrected before serious trouble develops, thereby considerably reducing the number of armatures and motors requiring complete overhauling.

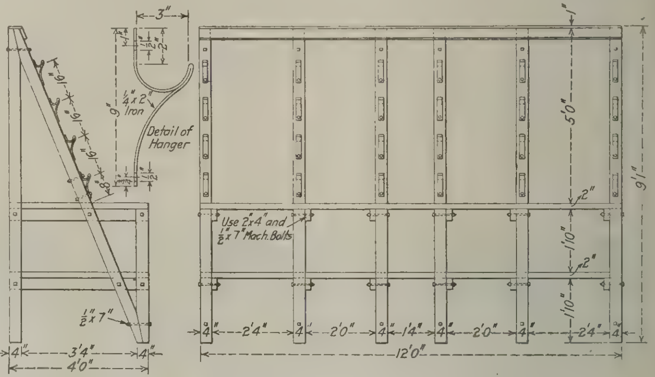


Fig. 5—Storage Rack for Incoming Work

In a repair shop that takes care of motor repairs on the rest of the road or division to which usually the entire motor is sent when it fails, the committee recommends the installation of a generator in the electrical shop for use in testing out these motors after they have been repaired. The motor to be tested should be belted to the generator and the generator loaded by means of a water rheostat. In this way the motor will have been thoroughly tested before being returned to its original location.

Facilities for Turning Commutators, Fitting Bearings, Etc.

It is the practice of a great many to turn over to the machine department the matter of turning commutators, fitting bearings, etc. It is recognized that a more efficient and higher standard of work can be accomplished by a machinist who is familiar with the layout, construction, limits and detail of the part or parts upon which he is working, in view of which the committee feels, where there is sufficient work to warrant, that an expert machinist be carried with the electrical force to take care of mechanical details of the work. This also gives the foreman the opportunity of expediting the repairs to any particular piece of work, which is not always possible when another department must be depended upon for this class of work.

Your committee recommends that the report be received as submitted and that the committee be discharged.

The Federal Board of Vocational Education has arranged for an electrical engineering education for each of 571 disabled ex-service men. These courses of instruction are being followed in various technical schools in different parts of the country. The institutions that have been selected for this purpose include nine schools in Massachusetts, five in New York City, five at other points in New York state, twelve in Pennsylvania, six in Ohio, six in Illinois, three in Indiana, three in Michigan, three in Iowa, three in Kansas, three in Missouri, three in Colorado and ten in California. In addition to the above institutional selection indicated, a number of the other states have been selected as having one or two schools in which engineering training is being secured by ex-service men under the jurisdiction of the Federal Board of Vocational Education. These states are as follows: New Hampshire, Vermont, New Jersey, Connecticut, District of Columbia, Maryland, Virginia, Georgia, North Carolina, Alabama, Mississippi, Louisiana, Kentucky, Wisconsin, Nebraska, Minnesota, Montana, New Mexico, Utah, Oregon,, Washington, Arizona and Texas.

Report of Committee on Power Trucks and Tractors

An Outline of the Factors Considered in a Cost Analysis of Material Handling Equipment

Committee

Louis D. Moore (chairman), electrical engineer, Missouri Pacific.

J. E. Gardner, electrical engineer, Chicago, Burlington & Quincy.

C. G. Winslow, assistant electrical engineer, Michigan Central.

James Barnett, power plant inspector, Baltimore & Ohio.

THE Committee on Power Trucks and Tractors was appointed to investigate the application of power trucks and tractors, both electric and gasoline, of the so-called industrial types, to the various phases of railway work. After careful consideration the committee prepared the following outline of questions which is proposed to consider:

Outline of Procedure

1. **Where is their use justified?**
    A. Tractors.
        (1) Gasoline.
        (2) Electric.
    B. Trucks, Load Carrying.
        (1) Gasoline.
        (2) Electric.
            (a) Baggage type.
            (b) Low platform type.
            (c) Elevating type.
    C. Trucks, Crane Type.
    D. Trucks, Stacking.
2. **Why is their use justified?**
    A. Direct money saved.
    B. Increase in quantity of material handled.
    C. Speed of handling.
    D. Labor difficulty.
3. **What savings effected, expressed in**
    A. Unit costs.
    B. Percentage of total cost of handling.
    C. Dollars and cents.
4. **Composition of costs.**
    A. Truck and tractor operation.
        (1) Fixed charges.
            (a) First cost of power trucks and tractors.
            (b) First cost of hand trucks.
            (c) First cost of charging plant and garage.
            (d) First cost of trailers.
            (e) Total first cost.
            (f) Interest on (e)................at..per cent.
            (g) Depreciation on (e).
                (1) Power trucks and tractors at..per cent.
                (2) Trailers.................at..per cent.
                (3) Hand trucks ....at..per cent.
                (4) Charging plant...........at..per cent.
                (5) Garage.
            (h) Taxes on (e).................at..per cent.
            (i) Insurance on (e).............at..per cent.
            (j) Total yearly fixed charges.
        (2) Maintenance charges.
            (a) Power trucks and tractors—repair parts, including motor and control.
            (b) Hand truck repair parts.
            (c) Battery repair parts.
            (d) Shop repair parts.
            (e) Labor on repairs.
            (f) Total maintenance charges.
        (3) Transportation costs.
            (a) Electric current........kwhr. at
                or gasoline........gals. at
            (b) Oil and grease.
            (c) Labor—charging batteries.
            (d) Labor—truck or tractor operators, helpers and hand truckers.
            (e) Total transportation charges.
    B. Hand trucking.
        (1) Fixed charges.
            (a) First cost of trucks.
        (2) Maintenance charges.
            (a) Repair parts.
            (b) Labor on repairs.
            (c) Total maintenance charges.
        (3) Transportation charges.
            (a) Oil and grease.
            (b) Labor—greasing and trucking.
            (c) Total transportation charges.
5. **Mechanical Details.**
    A. Drive.
        (1) 2-wheel or 4-wheel.
        (2) Chain or shaft.
    B. Steer.
        (1) 2-wheel or 4-wheel.
        (2) Lever or wheel.
        (3) Horizontal or vertical plane.
        (4) Clearance and position of steering column.
    C. Type of brake—on transmission shaft, axle or drum attached to wheel.
    D. Automatic brake.
    E. Automatic switch interlocking with brake and controller.
    F. Wheel size—recommendations as to application of various sizes.
    G. Tires.
        (1) Standard size.
        (2) Method of applying to wheels.
    H. Couplers and draft rigging.
    I. Capacity.
    J. Speed.
    K. Springs.
    L. Type of universal joint.
    M. Spare parts—wheels, differentials, universal joints, chains, transmission shafts, bearings for wheels and motors.
    N. Anti-friction bearings on trailers.
6. **Electric Details.**
    A. Batteries.
        (1) Type—merits and demerits of both types.
        (2) Capacity.
        (3) Number of cells or voltage.
        (4) Suspension.
        (5) Accessibility.
        (6) Extra batteries.
        (7) Type of connector.
        (8) Type of hold down.
        (9) Type of battery tray—roller bottom, etc.
        (10) Motor and battery protection.
    B. Controllers.
        (1) Resistance type.
        (2) Battery and field connection type.
        (3) Vertical drum.
        (4) Horizontal drum.
        (5) Face plate type.
        (6) Foot type.
        (7) Mechanical design.
    C. Motors.
        (1) Type.
        (2) Suspension.
        (3) Accessibility.
        (4) Extra motors.
    D. Wiring assembly.
    E. Auxiliaries.
        (1) Circuit breakers.

    (2) Ampere hour meter.
    (3) Odometers.
    (4) "Service recorders."
    (5) Fenders—front and rear.
  F. Battery charging equipment.

7. **Warning signals.**
8. **Types of tractors.**
    (a) 4-wheels.
    (b) 3-wheels.
9. **Types of trailers.**
10. **Auxiliary loading equipment.**
11. **Are extra machines justified?**
12. **Character of roadways.**
13. **Record and report forms.**
14. **Methods of investigating costs of proposed installation.**

In order to obtain the benefit of the experience of various railroad and industrial users of this equipment a questionnaire was sent out embodying the principal features of the above outline. While much valuable data was obtained, the replies were not sufficiently comprehensive to enable the committee to prepare a full report at this time.

In the following paragraphs the committee has considered the fact that usually shop roadways are not as good as they should be, and therefore has made allowances.

In general, gasoline equipment seems best suited for hauling light loads on streets and rough roadways, where grades are steep and distances considerable, and where a higher speed is desired than usually obtains with electric equipment.

Electric equipment is generally to be preferred for freight and baggage handling and for general hauling where roadways are good.

Either class of equipment is probably not economical for hauls of less than 500 ft.

Tractors, as a rule, are more suitable for freight handling, where it is often possible to load the trailers directly from the wagons, or vice versa, and for locations where tractors can be operated on a regular schedule for pick-up duty.

Load-carrying trucks are more suitable for irregular duty and for service in congested locations, such as mail and baggage service on passenger platforms.

The load-carrying trucks may be classified as baggage type, low platform type and elevating platform type.

The baggage type is fairly long and may have either high or low platform, the former being used where the station platform is low, so that the platform of the truck is even with the car floor, and the latter, at such stations that have station platforms even with the car floor.

The low platform type of truck is usually short and is suitable for handling heavy materials in congested spaces.

The elevating platform type of truck is somewhat similar to the low platform type above mentioned, but has the added feature that the platform can be raised (by power) several inches above its normal position, so that it may be run under a platform or bin supported on blocks or skids, the platform elevated, and the load moved as desired. This type of truck finds its best use in shop or factory service where large amounts of heavy material of the same kind are produced and moved short distances. This type of machine has the advantage over the plain low platform type, in that it requires only one operator and the truck itself does all the lifting.

There are also special types of electric trucks, among which are the crane type and the stacking or tiering type.

The crane type truck is essentially a low platform truck with an electrically operated jib crane on it for loading purposes, so that heavy castings, hoppers or material, motors and heavy finished parts requiring careful handling may be easily loaded without suffering damage. These cranes are sometimes equipped with lifting magnets which may be used for loading scrap or small castings.

The stacking or tiering truck is similar to the elevating platform type, except that the platform is capable of elevation of several feet. Its purpose is to enable boxes of heavy material, kegs of nails or bolts, sacks of cement, etc., to be piled to a considerable height in tiers or stacks.

The consensus of opinion seems to be that the use of power trucks and tractors effects great savings wherever they have been tried. The amount of savings over hand trucking are reported in various units, varying from

20 per cent to 75 per cent (total cost of operation).
14 cents to 20 cents per ton for freight.
85 cents to $1 per ton for stores material.
50 per cent on labor.
26 per cent return on investment.

One user also mentions the fact that less damage to material occurs with power trucking than with hand trucking. All agree that difficulty in obtaining labor is a very important reason for using these machines, and one user features this point, stating it was their only reason for installing them. Another great advantage in the use of this equipment is that, by handling material and shipments faster, freight house and store room congestion are relieved, thus increasing the amount of material handled, with the same overhead expense for buildings and trackage; also cars are released quicker, thus increasing the ton mileage per car.

In the matter of arriving at costs of operation, practice varies widely, some users taking into account most of the items enumerated above, while others consider very few of them. It is the committee's earnest recommendation that costs be very carefully kept and that the outline of "composition of costs" be adhered to as closely as possible.

In the matter of the mechanical and electrical details the committee at this time does not feel itself in a position to make any recommendation, but invites as thorough a discussion of these features as possible.

All power trucks or tractors should be provided with some sort of warning signal. This may be a bell (either electric or mechanical), or a horn. Whatever kind of signal is used, it should have a sound which is readily distinguishable from other sounds about the premises.

Of the three-wheel and four-wheel tractors the three-wheel machine is lighter and has a smaller turning radius than the four-wheel. It is also less expensive. On the other hand the four-wheeler is less likely to upset in making turns and is much more powerful than the three-wheel machine. It finds its best applicability in hauling heavy trailers in shops, packing plants, and is largely used in railway express service, while the three-wheel equipment is more generally used in freight house service.

With the gasoline tractor the standard baggage truck is used in baggage and mail service. For any class of service with this type of machine the trailer should have large wheels, preferably rubber tired.

With electric tractors in freight house work the ordinary four-wheel "jacks" used in freight houses, having two small swivelled wheels in front and two larger wheels toward the rear, seem satisfactory. They trail well in making turns, and if well greased are easily handled. A very useful type of trailer for freight house work is a standard two-wheel truck with small wheels or castors on the feet and a chain bridle for attaching them to the tractor. These are useful in handling barrels, sacks and heavy boxes for short distances. For use around shops and storehouses various types of special trailers may be used, but unless there are good roadways the wheels should be fairly large and preferably rubber tired.

Various types of auxiliary loading equipment may be desirable. With the elevating platform trucks, platforms or bins with skids or blocks permanently attached should be used. These supports should hold the bottom of the platform or bin just high enough to allow the truck to be run under it when the truck platform is at its lowest point. Truck platform is then elevated, lifting the bin or platform clear of the floor so it can be moved. Another type of convenient loading equipment is a low platform trailer equipped with a hand-operated crane.

It is the opinion of the committee that in all power truck or tractor installations there should be one or more extra machines, to allow for necessary shopping without impairing the service. This is especially true in installations of only one or two machines, as in such cases an outage means a larger proportion of traffic tied up. The number of extra trucks to be provided depends on local conditions, so that the committee does not feel qualified to make a definite recommendation in this regard.

The committee feels that too much emphasis cannot be laid upon the importance of good roadways, as they lengthen the life of the truck, increase quantity of material handled and speed of operation, reduce maintenance and cost of operation, reduce draft on batteries and eliminate a great deal of damage to material handled. In freight houses the floor, bridges, etc., should preferably be of matched flooring, and should be level. In shop grounds, runways should be provided, preferably of concrete, otherwise of planking or, at the very least, of chats or cinders, leveled off, packed hard and maintained free from ruts, gullies, holes or obstructions. The Santa Fe Railroad is a shining example to be followed in this respect, as at their Topeka shops they have concrete runways to all buildings and departments for the use of their motor equipment.

The committee does not at present feel qualified to make a recommendation as to record and report forms, other than that the matter be studied by the committee appointed next year, nor do they wish at this time to go into detail as to investigation of costs of proposed installations. This is a matter for careful study in each individual case, however.

At the outset of its work the present committee felt that it could do little more than outline the work to be done, and as its investigation progressed this feeling became a conviction. The difficulties encountered in connection with this investigation are probably different from those of other committees of the association, in that the tractor equipment on various roads is very largely under non-technical jurisdiction, such as freight agents, storekeepers, etc., and while in some instances maintained by regular electrical forces, in many cases it is not. For this reason the present committee recommends that this report be received and that the investigation started this year be continued next year by a committee appointed for the purpose.

Report of Committee on Stationary Power Plants

Table Has Been Prepared to Serve as a Guide for Determining Power Plant Equipment Required

Committee

L. C. Bowes (Chairman), supervisor stationary power plants, Chicago, Rock Island & Pacific.

W. J. Barnes, engineer power plants, Baltimore & Ohio.

G. O. Moores, chief draftsman, Baltimore & Ohio.

PART I.

Boiler Requirements, Power and Air Capacities for Engine Terminals.

The capacity and distribution chart which accompanies this report was compiled by your committee from data obtained from two railroads, one operating west and the other east of Chicago. While it was the committee's desire to obtain average values, nevertheless the information secured for the chart resulted in capacities which should be taken as a minimum for general cases, rather than an average.

Before considering the data contained in this chart, a few explanations will give a better understanding of it. Each column of the chart is numbered, and the following brief explanation refers to column numbers:

Column 1: Rated hp. Boilers.—Total capacity of all boilers, based on 10 sq. ft. heating surface per boiler horsepower.

Column 2: Type of Boilers.—Water tube (W.T.), horizontal return tubular (H.R.T.) and locomotive (Loco.).

Column 3: How Fired.—Stoker or hand fired (H.F.). For analysis of individual plants, this can be extended to take in the particular type of stoker.

Column 4: Kind of Fuel.—Screenings (Scrgs.) and Slack. For analysis of individual plants, this can be extended to take in the mine district or territory. In case oil or gas is burned, all fuel values should be reduced to coal basis for comparison.

Column 5: Approximate B.t.u.—based on dry coal. For analysis of individual plants, to be taken as average of laboratory analysis, if available. In absence of laboratory analysis, Bureau of Mines analysis for coal of same district can be taken.

Column 6: Tons per month. Average computed over one year. This average will be greater than summer consumption and less than winter consumption.

Column 7: Rated Capacity of Air Compressors.—Taken as total of all compressors based on builder's full rated capacity.

Columns 8 *and* 9: Summer and winter percentages chargeable against compressing of air.

Column 10: Rated hp., Engines.—Taken as total capacity of all engines based on builder's rating. This does not apply to generating units, but only to engines used as direct shop drive.

Columns 11 *and* 12: Summer and winter percentages chargeable against engines used in direct drive.

Column 13: Rated kw. of all generators, a.c. and d.c., builder's rating.

Columns 14 *and* 15: Summer and winter percentages chargeable against generation of light and power.

Column 16: Average kw. hrs. per month, based on consumption for one year, furnished from outside source, whether purchased from power company or furnished from another plant belonging to the railroad.

Column 17: Heat furnished in form of live steam for drying sand, oil house uses, and for washroom facilities.

Column 18: Same as column 17, but further includes live steam, furnished for building and roundhouse heating, but does not include live steam furnished to exhaust steam heating system in absence of sufficient exhaust steam.

Column 19: This includes live steam furnished exhaust steam heating system in absence of sufficient exhaust. This will be explained further in another part of the report.

Columns 20 *and* 21: Summer and winter percentages chargeable to pumping water. This includes all pumping except that for locomotive washout and fill-up systems, and stationary boiler feed pumps—also includes whatever steam is furnished water softening and treating plants where these plants are operated from shop and roundhouse stationary plant.

Columns 22 *and* 23: Summer and winter percentages chargeable to steam used on roundhouse blower lines for firing locomotives in house.

Columns 24 *and* 25: Summer and winter percentages chargeable to washing and filling locomotive boilers—also includes steam used by washout and fill-up pumps, and live steam used for heating, washout and fill-up water.

Columns 26 *and* 27: Summer and winter percentages chargeable to steam hammers, engine washing machines, and other miscellaneous steam users not otherwise detailed in chart.

Column 28: Number of locomotives through shop per month.—This refers to heavy classified repairs—average taken over one year.

Column 29: Number of freight cars repaired per month.—Average taken over one year. No distinction made between light, heavy and extra heavy repairs.

Column 30: Number of passenger coaches repaired per month.—Average taken over one year.

Column 31: Number of locomotives handled in roundhouse per month.—Average over one year. This does not mean engines despatched, but refers rather to the number of engine handlings, which is approximately twice the number of engines despatched.

The Capacity and Distribution Chart, Its Use and Limitations

This chart is purported to apply to very general cases, and does not include capacity and consumption necessary to supply eating houses and hotels, coach heating or other facilities served outside of the average shop and roundhouse plant. However, service for pumping stations, coaling stations, store and oil houses, and other buildings ordinarily found in

CAPACITY AND DISTRIBUTION CHART

Plant classification	Boilers			Fuel			Air capacity			Engine capacity			Generator capacity			Power from sources outside of power plant—Average kw. hours per month
	Rated hp.	Type	How fired	Kind fuel	Approx. B.t.u.	Tons per month	Rated cu. ft. per min.	Per cent total steam		Rated hp.	Per cent total steam		Rated kw.	Per cent total steam		
								Winter	Summer		Winter	Summer		Winter	Summer	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Back shop—1	3,000	W. T.	Stoker	Scrgs.	12,000	2,700	5,600	32	48	None	None	None	1,500	23	30	None
Back shop—2	2,500	W. T.	Stoker	Scrgs.	12,000	2,400	5,000	19	28	None	None	None	1,250	19	30	None
Back shop—3	1,000	W. T.	Stoker	Scrgs.	12,000	1,100	2,500	17	23	None	None	None	750	13	18	None
Heavy running repairs..........	600	H. R. T.	H. F.	Slack	12,000	700	1,000	14	17	None	None	None	200	14	20	None
Light running repairs...........	450	H. R. T.	H. F.	Slack	12,000	450	650	25	32	None	None	None	None	None	None	17,000
Roundhouse turning points	300	H. R. T. or Loco.	H. F.	Slack	12,000	250	150	26	35	None	None	None	None	None	None	5,000

Plant classification	Heating (Live steam) Per cent of total steam		Heating (Exhaust steam). Per cent of total steam. Winter only	Pumping water. Per cent of total steam		Blowing locomotive. Per cent of total steam		Washing boilers. Per cent of total steam		Steam, Other uses. Per cent of total steam		Number locomotives through shop per month	Number freight cars repaired per month	Number passenger coaches repaired per month	Number locomotives handled in roundhouse per month
	Winter	Summer		Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer				
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Back shop—1	5	2	20	3	3	None	None	None	None	17	17	35 to 50	1,500	25	None
Back shop—2	10	2	20	8	10	12	15	6	8	6	7	15 to 35	3,500	10	3,000
Back shop—3	10	2	20	4	5	21	30	8	12	7	10	0 to 15	3,500	25	3,000
Heavy running repairs	10	3	20	3	5	26	35	10	15	3	5	None	2,500	None	2,000
Light running repairs	25	3	5	7	10	22	30	13	20	3	5	None	2,000	None	1,000
Roundhouse turning points........	25	None	None	7	10	35	45	7	10	None	None	None	500	None	750

connection with operation of shops and roundhouses, is included in the chart.

It will be further noted that these data are based on a 12,000 B.t.u. heating value for coal. For better grades of coal, a decrease in installed boiler capacity and monthly fuel consumption would be expected. For poorer grades of coal, a corresponding increase of installed boiler capacity and increased monthly coal consumption would be expected. An increase in the number of freight cars handled would increase the charges on fuel consumption for compressing air, and a corresponding increase in installed boiler capacity and monthly fuel consumption. An increase in the number of engine handlings would also call for an increase in installed boiler capacity and monthly fuel consumption.

Where Eastern coals are burned, stoker installations, for the most part, would be the underfeed, forced draft type, which would permit of less installed boiler capacity, due to the higher rates of overload. Plants burning the Middle Western coals would probably require chain grate or other type of over-feed stoker.

In very large plants, conditions permitting, condensing generating units would be used, with possible use of mixed pressure and bleeder type steam turbines.

In general, each individual case should be carefully analyzed. The chart is meant to serve as a criterion rather than a hard and fast rule to cover all cases, and if it serves as a guide to the method and procedure in the analysis of power plant distribution, your committee will feel that its work has not been in vain.

Values for Estimating Steam Consumption

In a general way the following values can be used in estimating steam consumption of the various facilities served in connection with a railroad stationary plant. These values are supposed to represent operating averages rather than test conditions, allowing for condensation, etc.:

1. Actual evaporation: 5 lb. of water per lb. of coal.
2. Boiler hp.: 30 lb. actual evaporation.
3. For blowing locomotives: 50 boiler hp. per locomotive hr.
4. For coach heating: 3 to 5 boiler hp. per coach hr.
5. For roundhouse heating: Exhaust steam with vacuum returns—600 lb. per 1,000 sq. ft, radiation per hr.
6. For shop heating: Exhaust steam with vacuum returns —300 lb. per 1,000 sq. ft. radiation per hr.
7. Stationary engines: Non-condensing.
   Simple slide valve: 50 lb. per hp. hr.
   Simple high speed automatic: 35 lb. per hp. hr.
   Compound .... 30 lb. per hp. hr.
   Turbines (35 to 50 kw.): 50 lb. per hp. hr.
   Turbines (100 to 500): 40 lb. per kw. hr.
   Simple: 30 lb. per hp. hr.
   Compound: 25 lb. per hp. hr.
   Turbine (250 to 500 kw.): 27 lb. per kw. hr.
8. Air compressors:
   Two-stage: 100 lb. per 1,000 cu. ft. free air compressed to 100 lb. gage.
   Single stage: 150 lb. per 1,000 cu. ft. free air.
   Air Pumps: 600 lb. per 1,000 cu. ft. free air.
9. Injectors: 700 to 800 lb. per hp. hr.
   Syphon ejectors: 500 lb. steam per 1,000 gal. water delivered.
10. Steam Pumps: Consumption dependent upon many varying factors. Available data not in such shape as to be of much value.

Distribution of Heating Charges

Referring again to column 19 of the chart. Exhaust steam used for heating:

At this writing there seems to be no standard method of charging against heating, and crediting to facility, exhaust steam. However, two methods are being used. These are:

1. Consider exhaust steam as a by-product, and make entire charge against facility, using live steam and delivering exhaust steam.
2. Consider the power obtained from facility using live steam and delivering exhaust steam, as a by-product, the engine or other steam user merely acting as a reducing valve, and making the entire charge against heating.

It is readily apparent that neither of these is strictly accurate, and that the proper method lies somewhere between. Although your committee refrains at this time from making a recommendation as to the proper distribution, in absence of sufficient data, it would seem that each facility should be charged with what it actually uses, bearing its share of overhead and unavoidable losses. And as a basis for discussion, your committee suggests that such equipment using live steam and delivering exhaust steam for heating, should bear a winter charge of only 10 per cent. of its estimated steam consumption under summer conditions, the remaining 90 per cent. being charged against heating, and pro-rated between the departments. This has not been done in the distribution shown on the chart. Only live steam that is needed in addition to the exhaust steam, to make up for deficiency of exhaust, is charged in the distribution as shown on the chart. However, the winter distribution, based on the above suggestion, can be made readily from the summer distribution shown on the chart.

A few further additional remarks concerning the conditions assumed for plants as outlined in the chart:

Shops for handling of heavy classified repairs are given for three different sizes of plants. The first size is a plant engaged in back shop work only, with no roundhouse work in connection with it. Shops of the next two sizes are considered in connection with roundhouse, but are of a smaller size. Plants of this class should be analyzed very carefully. The question of power plants involves much the same proposition as the question of central power stations, since production of power is of first importance. The boiler plant should consist of water tube boilers, stoker fired, and should be of the most approved design, equipped with adequate coal and ash handling systems. Probably in no case would such a plant be designed to purchase power from outside sources and shops should be entirely electrified after the most approved practice.

Plants of the second classification are those terminal points handling heavy running repairs and considerable roundhouse work. The capacity of such plants would ordinarily not be sufficient to warrant water tube boilers and stokers. However, generally speaking, these plants could well afford to generate their own power, unless an extremely low rate for purchased power could be secured. Blowing locomotives is the heavy end of the steam load in such classes of plants.

In plants handling light running repairs and roundhouse work, the same conditions hold true, except that in most cases it would be economical to purchase power from some outside source, unless the rates were excessively high, the service poor, or outside power unavailable. In this event, small engine drives would probably be the most economical, although installation of some generating units should be carefully considered.

The last class of plants, i.e., small roundhouse turning points, there is very little doubt but that the purchase of power from outside sources would be the most economical. Very little power would be required, the largest load being that of blowing locomotives. Boiler capacity required in this class of plant would seldom exceed 150 boiler horsepower. However, it is not good policy to install only a single boiler unit, for no allowance is thus made for washing and general maintenance work. Locomotive boilers could well be used in such class of plants. Your committee does not recommend the purchase of locomotive type boilers, nor does it recommend the widespread use of locomotive type boilers. However, old locomotive boilers could well be used in this smaller class of plants, rather than spending large sums for the purchase of new boilers.

In the first three classes of plants—i.e., heavy back shop, heavy running repairs and light running repairs—it is assumed that hot water locomotive washout and fill-up plants would be installed.

It will be noted that in none of the classes of plants shown on the chart are engine units, directly driving shops, recommended. However, there would probably be a number of cases where small engines could be used to advantage, rather than consign them to scrap, particularly at such smaller points where outside service is unreliable or cannot be secured.

Before leaving the consideration of the chart, a few words regarding the further analysis of power plant distribution charges would not be amiss. Once having a distribution chart worked up for any particular plant, it is well to check back these percentages on the actual cost of operation of the stationary plant. Reducing it thus to dollars and cents, a very good check is readily obtained.

In connection with the chart, it would be well to touch upon the problem of purchased power versus generation of power within the plant. Such a problem requires very careful analysis of all conditions. It may resolve itself into a question of business policy and expediency. The location of the plant, whether north or south, also has considerable bearing on the subject. There are no hard and fast rules that can be laid down. Each case requires individual consideration.

PART 2

Modernization of Stationary Plants to Better Adapt Them to Existing Conditions.

The problem of modernizing existing stationary plants, resolves itself, under the present high cost of labor and material, into a question of intensified maintenance. In the past, it has been the policy to neglect a considerable portion of the upkeep and maintenance of a stationary plant, which in a number of cases was an economical and a proper thing to do, particularly when fuel and labor were cheap. But now it is a big problem to get the maximum of efficiency and capacity from our plants with the least expenditure. For simplicity we will divide our plants into two sections: *A*, steam generating, and *B*, steam distribution and use.

A—Steam Generating

The most important point in the efficient generation of steam is to have clean boilers. A dirty boiler cuts the capacity and efficiency of the plant right at the source.

In H.R.T. boilers, one of the biggest failings is the clinkering of the flues in the combustion chamber. It is no uncommon thing to find half of the flues partly closed by clinker formation, and many times 10 per cent. of the flues will be entirely closed with clinker.

This clinker formation can be generally attributed to: 1. Leaky flues. 2. Wet steam used in blowing flues. 3. Neglect in blowing flues. 4. High rates of combustion. 5. Poor grade of coal with low fusing ash.

The first three of these causes can be eliminated, and the last two cannot.

1. Leaky flues are due to several causes. A dirty boiler that is allowed to run for a considerable length of time without cleaning, sometimes results in leaky flues when the boiler is cleaned. This can be taken care of by keeping boilers more uniformly clean.

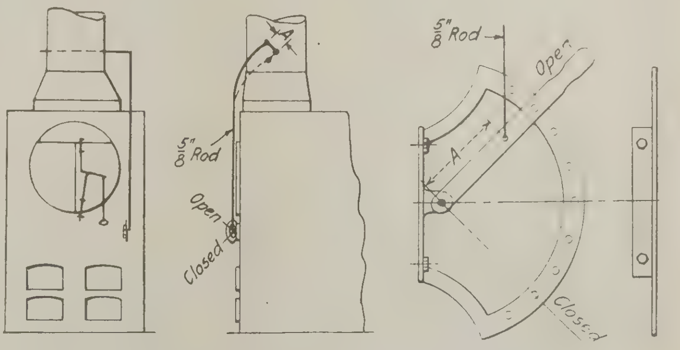


Fig. 1—A Simple Damper Control

Variation in temperature due to poor firing (allowing holes to burn in fire), excess air in thin fires, or cold air when cleaning fires, causes flues to leak. This can be overcome by regulating the damper according to the load and thickness of fire, and more uniform firing will overcome this cause. A simple damper control is shown in Fig. 1.

Leaky flues can be remedied, once the cause is removed, by the boilermaker force. Welding a bead around the flue is very effective in overcoming leaky flues.

2: Wet steam in blowing flues can be eliminated by properly draining flue blower line before blowing flues, by taking flue blower line from highest point in header to obtain dry steam, and by regrinding or replacing leaky valves on flue blower lines. Leaky valves allow blower line to fill with water is blown in on the flues.

3: Neglect in blowing flues is purely a matter of instruction and supervision by the local forces. Flues should be blown at least once every eight hours.

4 & 5: High rates of combustion and low fusing ash will clinker flues; these causes cannot be eliminated. Therefore they must be watched and a means adopted for removal of the clinker. This can be done by boring or scraping flues at least once a week, or oftener if rate of clinker formation warrants. The combustion chamber end is the place to determine whether or not flues are cleaned, not the smokebox end.

Scale and Mud Cause Dirty Boilers

Internal scale formation and mud are the causes of dirty boilers, considering the water side of the tube. This must either be eliminated by water treatment or use of compounds, or by manual persuasion with the flue rattler and scale hammer. The use of treated water and boiler compounds is aside from the scope of this report at the present time, but a campaign on the consistent use of scale removers in form of rattlers and scale hammers is of prime importance. If these tools are used frequently, no damage will result to the boiler steel by their use. If, however, boilers are allowed to run until the scale becomes very heavy, extremely heavy blows are necessary to dislodge the scale, oftentimes resulting in loosening of flues and seams. A flue rattler is just as important a part of the equipment of a stationary plant as the water glass or steam gage.

No fixed rule can be laid down as to the frequency of washout. That will have to be determined from experience and observations. But this much is certain—a stream of water is usually very ineffective for dislodging scale. In connection with keeping boilers clean, it is worthy of mention that the blow-off valve will remove some of the foreign substances within the boiler. Boilers should be blown off at least once in eight hours and oftener, depending on water conditions.

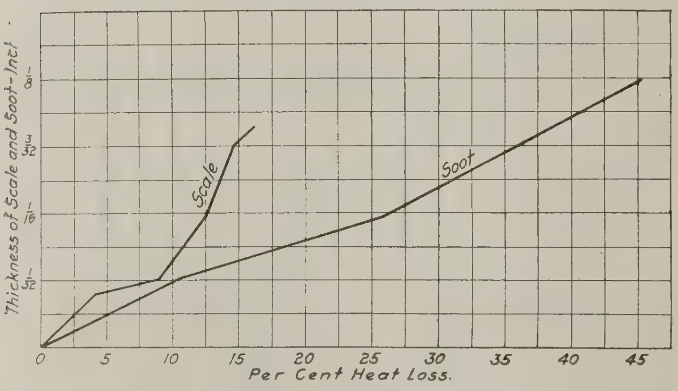


Fig. 2—Heat Loss Due to Scale and Soot

A few precautions regarding the use of scale remover may well be borne in mind. Coal oil has been used effectively, but great care should be exercised in its use, or oil burns will result. Any scale remover placed in a badly scaled boiler will almost always bring down large amounts of scale. Be sure that the boiler is not fired up when this scale does come down, or bagged and burned sheets will always result.

The curves shown in Fig. 2 have been published in various trade and engineering journals; they are included with this report to illustrate the enormous heat loss resulting from dirty boilers.

Brick Setting, Air Leakage, Fire Brick Lining, Feed Water Heater, Valves and Fittings

The next consideration, after having 100 per cent. clean boilers, is the brick setting. A brick setting, to obtain the highest efficiency and capacity out of the boilers, should be as nearly air tight as it is possible to make it. Most settings will allow of more or less pointing up, and when this has been done, the entire outside of the setting should be covered with a plastic material, which will retain its plastic qualities under action of the heat and against time. The next place to look for air leaks is around the boiler front, smokebox and firebox doors. The fire doors should fit the frames tightly and be easily swung open. They should be made so that a slight shove will close them tightly.

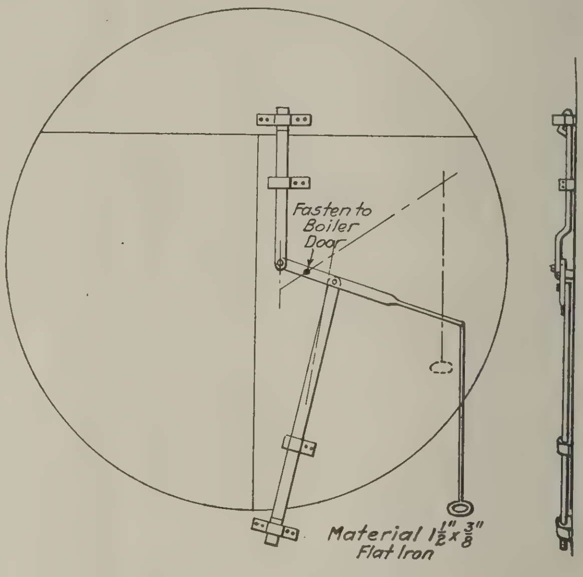


Fig. 3—Clamp for H. R. T. Smoke Box Doors

Smokebox doors should be hung in such a manner that they will close tightly against the front. Doors that are kept tightly closed will not warp. A type of door clamp that is cheaply made and easily applied is shown in Fig. 3. This clamp has been found very effective in keeping smokebox doors tightly closed.

The next point to look for air leakage is at the clean-out door of the combustion chamber and at the rear arch. If the clean-cut door frame is securely fastened to the brick, the door can be kept tightly closed by putting on a screw clamp. If the rear arch is of the flat suspended construction, made of tile hung on steel beams or rails, allowance being made for expansion between the boiler and arch, and this space filled with fibre asbestos, the setting will be reasonably air tight.

The next consideration is of the firebrick lining. The combustion chamber and firebox lining should be put in good shape, repairs being made with plastic firebrick, if the old lining is not too badly burned and cut out. Setting up arches over the fire doors, and under smokebox frame, plastic firebrick will do much to eliminate arch trouble.

The feed lines, valves, water column and steam gauge connections should be carefully inspected and care taken to see that these fittings are clean and in working order. The same should be done with blow off lines and valves, header valves and safety valves; the grates fully repaired and made to work freely. A stationary plant grate should have small air openings, but a large percentage of air space and should be of the shaking type. Then the boiler can be considered in A-1 shape to operate. If this is done often enough to keep it in this condition at all times much will have been done to increase the efficiency and capacity of the plant.

The next thing to do is to overhaul the feedwater heater and pumps. The heater is much the same as a boiler, and should be cleaned and sealed frequently. Safety devices, overflow device and vent must work properly. Adjustment of the float and overhauling float operated valve will usually be a means of saving water. The suction line from the heater should always be fitted with a thermometer, and it is one of the operator's duties to see that this thermometer never registers less than 200 degrees. Feed pumps must be kept fitted with tight valves in the water end and the proper kind of hot water packing used and properly applied. A failure of a feed pump may very easily result in a shutdown of the entire plant.

B—Steam Distribution and Use

The greatest loss in a steam distributing system other than from leaky valves and fittings is caused by uncovered steam lines. It is unnecessary to discuss this subject to any great extent, since everyone is familiar with the troubles that result from their use. However, the curves shown in Fig. 4, which are self-explanatory, illustrate the losses that occur in bare and covered steam lines, and the possible saving due to covering them.

It has been the practice in the past to run a perfect net work of pipe lines in any and all directions, about a foot or 18 in. underground. Sometimes there would be as many as three or four lines running parallel, possibly delivering the same service. But no one knew where these lines led, nor from what point they were taken. This practice, fortunately, is disappearing quite rapidly, but there are still a few such plants. These should be revised in favor of the overhead, properly lagged header and branch line system. No lines should be installed or extended without carefully analyzing the whole situation, and then the work should be done in accordance with approved methods. Even temporary lines should be put in with the idea of saving steam wherever possible, and when the temporary work has served its purpose, it should be removed immediately.

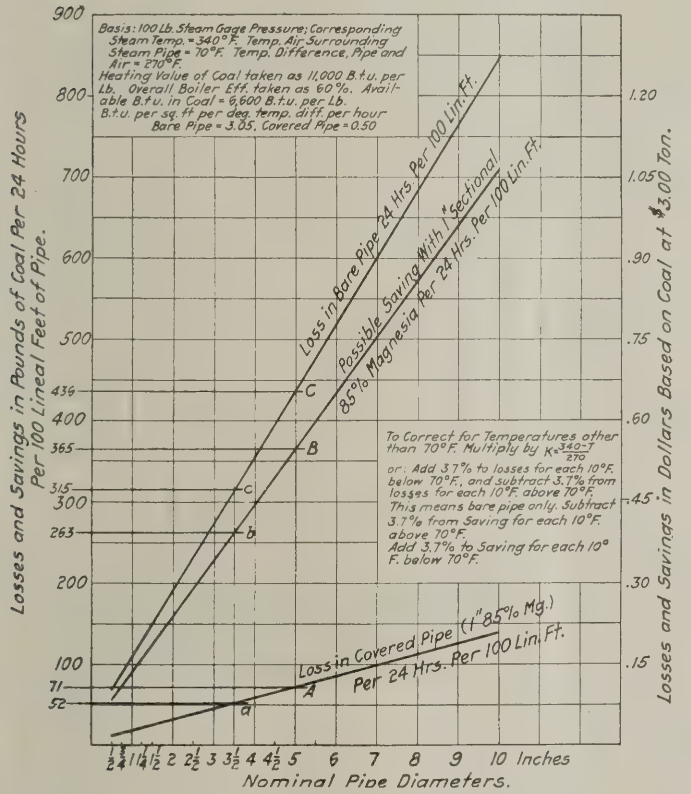


Fig. 4—Loss in Bare and Covered Steam Lines and Possible Saving Due to Covering

Steam using equipment may be divided into two classes: 1: That service where steam is used directly for heating water, blowing locomotives, etc., and 2: That service where steam is used for the production of power, such as pumping, generation of either mechanical or electrical power, steam hammers, etc. Where steam is used indirectly for heating water (i.e., through a coil and not by direct contact), all drain lines should be trapped to prevent waste of steam. Where steam is used directly in the water for heating, there is not so much chance of waste. However, this latter method is unsatisfactory as it is difficult to control the temperature of the water.

The blowing of locomotives requires an enormous amount of steam. It is possible that a nozzle could be designed and installed in the front end of a locomotive that would greatly reduce the steam consumption and the time of blowing locomotives. This is a point that would bear considerable investigation. However, under the present system, it is essential that care be taken to see that a locomotive is placed on its own blower just as soon as the pressure becomes high enough to permit.

Under the second classification of steam users are all reciprocating and turbine units. This equipment requires careful maintenance to keep the steam consumption reduced to a minimum. It involves the problem of proper care of packing and valves for pumps, and of valves, bearings and lubrication of other types of equipment. One of the first requisites to the efficient and continuous operation of a reciprocating unit is the perfect alignment of all moving parts. Unfortunately, this is not fully appreciated by most railroad mechanics, and applying the same rules to stationary engines that are used in locomotives results in a considerable amount of grief. The two are absolutely different. A locomotive has a floating gear and center of rotation, flexible within certain limits. This is necessary because of the type of service in which it is used. This is compensated for by large clearance spaces between pistons and cylinder heads, and lateral clearance in rods and bearings.

A stationary engine has an absolutely fixed center of rotation, small clearance spaces, and lateral as small as to be only a bearing fit. Therefore stationary engines must be in perfect alinement to operate properly, otherwise broken rods, hot bearings and grief in general will be the result.

The use of a steam engine indicator, and careful analysis of the diagrams obtained will point out many ways of reducing steam consumption. An adequate oiling system on stationary engines will do much to reduce the cost of lubrication; it will reduce the maintenance of bearings and in this way give better service.

In closing, your committee wishes to leave this thought with you: for efficient operation of power plants, it is absolutely necessary that each problem connected therewith be carefully analyzed. While it is hoped that this report may be an aid to those who read it, there can be no absolute rules drawn covering all cases. And it is well to remember that the operator, the man on the job, can do much to waste or save. Therefore, it should not be overlooked that the investment that will bring the biggest, the quickest, and the most lasting returns is an efficient force of engineers and firemen.

Your committee recommends that this report be received and the committee continued.

* * * *

Photo from "International"

Snowshed 76 on the Alaskan Government Railway

Report of Committee on Heavy Electric Traction

Extensive Chart Gives Valuable Data on Many Important Features of Electrification Work

Committee

J. R. Sloan (chairman), chief electrician, Central region, Pennsylvania System.
C. H. Quinn, chief electrical engineer, Norfolk & Western.
J. H. Davis, electrical engineer, Baltimore & Ohio.
F. E. Geibel, assistant electrical engineer, Southern Pacific.
J. A. Shaw, general electrical engineer, Canadian Pacific.
C. P. Kahler, electrical engineer, Oregon Short Line.

YOUR committee on Heavy Electric Traction, after discussing the subject by correspondence, drew up a series of questionnaire sheets designed to give in a condensed manner as much information as possible.

You will note that reference to any multiple unit operation has been almost entirely omitted. Your committee regrets this, and also that the data as presented is not more complete, but press of work due to the railroads being turned back to corporate control, reorganization of the railroads, etc., made such demands on the committee that time was not available to follow the matter up properly and obtain the missing data.

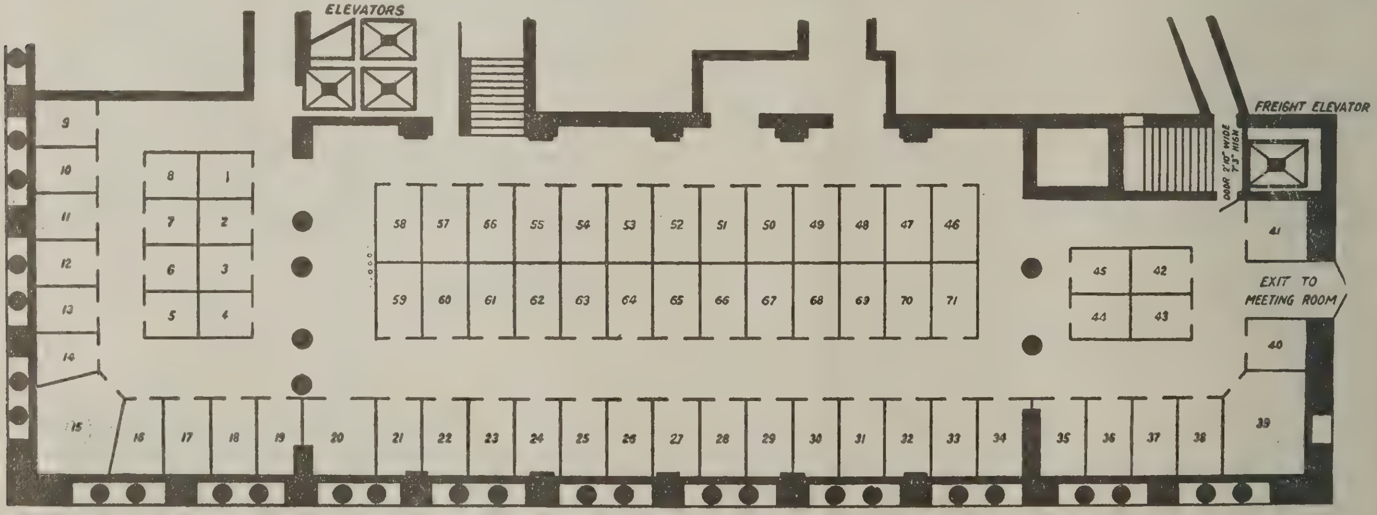
The report is, therefore, presented merely as a progress report, with the recommendation that the committee be continued to further elaborate it the next year.

The following table will show the yearly mileage and total mileage electrified:

Year.	Track Miles Electrified	Yearly Mileage	Total Mileage
1905	23	23	
1906	23 + 150 + 44	217	240
1907	23 + 38 + 44 + 35 + 103	243	483
1908	23 + 12 + 44 + 35 + 7	121	604
1909	23 + 35 + 7 + + 8	73	677
1910	23 + 35 + 97 + 20	175	852
1911	23 + 35 + 115 + 22	195	1,047
1912	23 + 35 + 208	266	1,313
1913	23 + 35 + 91 + 18	167	1,480
1914	50 + 185	235	1,715
1915	50 + 94 + 26	170	1,885
1917	20 + 440	460	2,345
1918	12	12	2,357
1919	+ 25	25	2,382
1920	220	220	2,602

Arrangement of Manufacturers Exhibits

Competing for attention as usual at the Railway Electrical Engineers convention will be the exhibits of the various companies comprising the Railway Electric Supply Manufacturers' Association. The exhibits will be found located in accordance with the diagram. For convenience a list of companies exhibiting, arranged in alphabetical order, is here given. Any company exhibiting but not shown in the list indicates that the name was received too late for publication.



Layout of Exhibits on the 9th Floor of the Auditorium Hotel

EXHIBITORS AT THE A. R. E. E. CONVENTION

Firm Name.	*Space No.*
Anderson Mfg. Co., Albert & J. M.	67
Benjamin Electric Mfg. Co	29
Bryant Electric Co	31
Central Electric Co	20, 21
Chicago Fuse Mfg. Co	26
Crouse-Hinds Co.	46, 47, 70, 71
Dodge Sales & Engineering Co	66
Edison Storage Battery Co	54, 63
Electric Service Supplies Co	1, 2
Electric Storage Battery Co	42, 43, 44, 45
Fairbanks, Morse & Co	32, 33, 34
Franklin Railway Supply Co	13
General Electric Co	55, 56, 61, 62
Gould Storage Battery Co	22, 23, 24
Hart & Hegeman Mfg. Co	37
Hazard Mfg. Co	30
Kerite Insulated Wire & Cable Co	50
Loco Light Co	51
National Lamp Association	39, 40
New Jersey Car Spring & Rubber Co	64
Oliver Electric Co	35, 36
Pyle-National Co.	27, 28
Railway Electrical Engineer	59
Safety Car Heating & Lighting Co	68, 69
S K F Industries, The	38
Sunbeam Electric Mfg. Co	53
Thompson Electric Co	25
U. S. Light & Heat Corp	57, 58
V. V. Fittings Co	60
Western Electric Co	52, 65
Westinghouse Electric & Mfg. Co	48, 49

IONS	Motor generators				Tl co Miles	
ting	Number	Type	Rating each	Current, voltage, phase, cycle	Route	Tr
0 kw.	...	....	......	600 volts d. c.	3 6	7.
					....	..
....	....	....	......	11,000 v. a. c., 1 φ, 25 ~	....	..
....	7-G.E.	1,200-2,400 v.	1,000 kw.	....	...	..
....	9-G.E.	3 unit syn. motor	1,500 kw.	3,000 volts d. c.	....	..
	26-G.E.	3 unit syn. motor	2,000 kw.	....	....	..
		....	......	....	...	...
		....	......	....	...	..
....	13-G.E.	3 unit syn. motor	2,000 kw.	....	....	.
....	8 West	3 unit syn. motor	2,000 kw.	....	....	.
....	..	....	......	[6]11,000 v. a. c., 1 φ, 25 ~	....	.
		....	......	3,300 v. a. c., 1 φ, 25 ~	..	..
....	..	....	......	....	....	.
....	...	....	......	600 volts d. c.	88.63	
....	...	....	......	....	....	.
....	2-G.E.	....	[5]1,000 kw.	....	....	.
p. 20,000 kw. " 245,000 kw.	...	....	......	....	...	..
....	...	....	......	11,000 volts a. c., 1 φ, 25	...	.
....	...	....	......	[6]11,000 v. a. c., 1 φ, 25 ~	....	.
				[7]11,000 v. a. c., 1 φ 25 ~	...	.
				[8]11,000 v. a. c., 1 φ, 25 ~	....	.
				[9]11,000 v. a. c., 1 φ, 25 ~	....	.
				[10]11,000 v. a. c., 1 φ, 25 ~	....	.
				[11]11,000 v. a. c., 1 φ, 25 ~	...	.
....	...	....	......	[13]11,000 v. a. c., 1 φ, 25 ~	....	.
....	...	....	......	[14]11,000 v. a. c., 1 φ, 25 ~	....	.
....	...	....	......	11,000 v. a. c., 1 φ, 25 ~	....	.
....	...	....	......	11,000 v. a. c., 1 φ, 25 ~	....	.
0 kw.	...	....	......	1,200 v. d. c.	....	.
00 kw.	...	....	......	600 v. d. c.	....	.
....	...	....	......	11,000 volts a. c., 1 φ, 25 ~	....	.
....	...	....	......	1,500 v. d. c.	....	.
....	...	....	......	1,200 v. d. c.	....	.
....	....	....	......	6,600 a. c., 1 φ, 25 ~	...	.
....	...	....	......	3,300 v. a. c., 1 φ, 15 ~	....	.
....	2-G.E.	1,200/2,400	1,500 kw.	2,400 v. d. c.		

DATA ON HEAVY ELECTRIC TRACTION IN UNITED STATES AND CANADA.

			Specific cause of electrification	Began Electrical Operation	Miles Route	Main Line	Yards and Sidings	Total Single Track	System of Electrification	Power Supply, Chief Source	Generated or Purchased	POWER GENERATION No. Prime Movers and Rating	Voltage, current, phases, cycles	Per cent power regenerated	POWER TRANSMISSION Number Circuits	Size	Conductors Material	Spacing	Ave. Span	Insulators Make	Type	Poles material	Voltage current phases cycles	SUB-STATIONS Number	Type	Spacing miles	Transformers Number	Type	Rating	Ratio	Rotary converters Number	Type	Rating	Motor generators Number	Type	Rating each	Current, voltage, phase, cycle	Third rail construction Miles Route	Track	Size rail	On side	Gage line running rail to gage line 3rd rail Horizontal	Vertical	Bonds			
[illegible]	[illegible]	Heavy pass. and freight	Tunnel and terminal	1895	3.6			7.96	600 Volts, d. c.	Consolidated Gas, Electric Light & Power Co	Purchased			0.00										3							5	G. E.	1,000 kw				600 volts d. c.	3.6	7.96		top						
[illegible]	[illegible]	Heavy pass. and freight	Tunnel	May 1911	7.97	15.94	5.56	21.5	11,000 V., 1 φ, 25 ~	Railroad Power Plant	Generated	2 W. E. & Mfg. Co., 3,000 kw. turbo	11,000 Volts a. c., 3 φ, 25 ~	0.00	2	4/0						Steel	11,000 volts a. c., 1 φ, 25 ~	3	Switching												11,000 v. a. c., 1 φ, 25 ~										
[illegible]	[illegible]	Heavy pass. and freight	General economy	1913	30			114	2,400 V., d. c.	Great Falls Power Co, hydro electric	Purchased													2	Motor generator									7 G. E.	1,200/2,400 v	1,000 kw.											
[illegible]	[illegible]	Heavy pass. and freight	General economy	Dec 1915	440	440	210	650	3,000 V., d. c.	Montana Power Co	Purchased		2,300 Volts a. c., 3 φ, 60 ~	1								Wood	100,000 a. c., 3 φ, 60 ~	14	Motor generator	30	9 26	O. I., W. C., 3 φ O. I., W. C., 3 φ	1,900 k.v.a. 2,500 k.v.a.	100,000:2,300 100,000:2,300				9 G. E. 26 G. E.	3 unit syn. motor 3 unit syn. motor	1,500 kw. 2,000 kw.	3,000 volts d. c.										
[illegible]	[illegible]	pass. and freight	General economy	1919	217			250	3,000 V., d. c.	Washington Water Power Co Puget Sound Tr., Lt., & P. Co.	Purchased Purchased				1	2/0	Copper					Wood	100,000 a. c., 3 φ, 60 ~	5 3	Attended motor gen. Attended motor gen.		13 G. E. 8 West	O. I., W. C., 3 φ O. I., W. C., 3 φ	2,500 k.v.a. 2,500 k.v.a.	100,000:2,300 100,000:2,300				13 G. E. 8 West	3 unit syn. motor 3 unit syn. motor	2,000 kw 2,000 kw											
[illegible]	[illegible]			June 1907	[illegible]	34	4	38		Ontario Power Co	Purchased												60,000 a. c., 3 φ, 25 ~	1	Transformer		3	O. I., W. C., 1 φ	750 k.v.a.	60,000:11,000							11,000 v. a. c., 1 φ, 25 ~										
[illegible]	[illegible]	Heavy pass. and freight	Tunnel-St. Clair River	May 1908	3.8	6.5	5.5	12	11,000 V., a. c., 1 φ, 25 ~	Grand Trunk P. P.	Generated	2 West. 1,250 kw. turbo generators	3,300 Volts a. c., 3 φ, 25 ~																								3,300 v. a. c., 1 φ, 25 ~										
[illegible]	[illegible]	Heavy pass. and freight	Tunnel	1909	4.0			10	6,600 V., a. c., 3 φ, 25 ~			3 G. E. 2,000 kw. water wheel gen.												1	Transformer		4 G. E.		850 kw																		
[illegible]	[illegible]	Suburban pass.	Traffic congestion	June 1905	88.63	187.1	20.9	208	600 V., d. c.	Long Island Power Plant	Generated											Steel	11,000 v. a. c., 3 φ, 25 ~	11													600 volts d. c.	88.63	208	100, 150	top						
[illegible]	[illegible]	Heavy pass. and freight	Tunnel and terminal	1910	6.25			24	600 V., d. c.	Detroit Edison	Purchased													1										2 G. E.		1,000 kw											
[illegible]	[illegible]	Heavy and suburban pass.	Tunnel and terminal	1906	34			268	600 V., d. c.	Port Morris and Glenwood	Generated	6 G. E. turbines, total cap. 60,000 kw.																			1 1	G. E. West	total cap. 20,000 kw " " 245,000 kw														
[illegible]	[illegible]		Connecting P. R. R. and N. Y. N. H. & H.	1918	5.5			11	11,000 V., a. c., 1 φ, 25 ~	Cos Cob Power Plant	Generated												22,000 v. a. c., 1 φ, 25 ~														11,000 volts a. c., 1 φ, 25 ~										Catenary
[illegible]	[illegible]	"	Terminal and general economy	July 1907	[illegible]3.2	329.4	202.3	531.7	11,000 V., a. c., 1 φ, 25 ~	Cos Cob Power Plant	Generated	3 West. turbo generators, 3,000 kw 4 West. turbo generators, 4,000 kw 1 West. turbo generators, 6,000 kw	11,000 Volts a. c., 3 φ, 25 ~									Steel bridges	22,000 v. a. c., 1 φ, 25 ~	22	Transformer, remote	3.5	1	Auto, O. I., S. C., 1 φ	[illegible],000 k.v.a.	22,000:11,000							11,000 v. a. c., 1 φ, 25 ~ 11,000 v. a. c., 1 φ, 25 ~ 11,000 v. a. c., 1 φ, 25 ~ 11,000 v. a. c., 1 φ, 25 ~ 11,000 v. a. c., 1 φ, 25 ~ 11,000 v. a. c., 1 φ, 25 ~								21.5 1.78 9.69	86 7.1 58.1	Double catenary Compound catenary Compound catenary Single catenary Compound catenary Single catenary
[illegible]	[illegible]			1912	18.23	49.6	3.96	52.56		Cos Cob Power Plant of N. Y. N. H. & H.	Purchased				4	4/0	Copper	3' 1" Hor. 5' 0" Vert.	300'-400'			N. H. bridges, steel	22,000 v. a. c., 1 φ, 25 ~	3	Transformer		1	Auto, O. I., S. C.	2,000 k.v.a.	22,000:11,000							11,000 v. a. c., 1 φ, 25 ~ 11,000 v. a. c., 1 φ, 25 ~ 11,000 v. a. c., 1 φ, 25 ~								7.9 8.5 2	31.6 17 4	Compound catenary Compound catenary Single catenary
[illegible]	[illegible]			1914	26			90	11,000 V., a. c., 1 φ, 25 ~	Blue Stone Power Plant	Generated	4 West. turbo generator, 10,000 kw	11,000 Volts a. c., 1 φ, 25 ~		2	2/0	Copper		360			On trolley poles	44,000 v. a. c., 1 φ, 25 ~	5	Transformer			West. O. I., W. C., 1 φ	4 2,000 k.v.a. 6 3,000 k.v.a. 2 5,000 k.v.a.	44,000:11,000							11,000 v. a. c., 1 φ, 25 ~								26	90	Single catenary
[illegible]	[illegible]			July 1912	122	154	35	180		Port. Ry., Lt. & P. Co.	Purchased		60,000 Volts a. c., 3 φ, 33 ~		1	105,530 c. m.	Aluminum	6' 0" △				Wood	60,000 v. a. c., 1 φ, 33 ~	8 1	Housed Portable			3 φ			13	G. E.	500 kw				1,200 v. d. c.								122	180	Single catenary
[illegible]	[illegible]			1912	18.73	46.73	50.76	97.49	600 V., d. c.	Long Island Power Plant	Generated	2 West. turbo generators, 5,500 kw. 2 West. turb. generators, 8,000 kw 1 West. turbo-generator, 20,000 kw				250,000 c. m.	Copper	3 Cond., lead	Underground				11,000 v. a. c., 3 φ, 25 ~	4	Converter		36	A. E.	750 k.v.a.		12		2,000 kw				600 v. d. c.			150, 25	over						
[illegible]	[illegible]			Paoli Sept. 1915 Ch. Hill Apr. 1918	30.5			116.3	11,000 V., a. c., 1 φ, 25 ~	Philadelphia Electric	Purchased		13,200 Volts a. c., 3 φ, 25 ~		1	2/0	Copper	5' 0" Hor. 3' 6" Vert.				Steel	[illegible]	6	Remote control		6 6	1 φ	[illegible]000 k.v.a. 3,000 k.v.a.	[illegible]							11,000 volts a. c., 1 φ, 25 ~								30.5	116.3	Single catenary
[illegible]	[illegible]			Jan. 1914 June 1911	146 52.25	 100.81	 14	162 114.81		Portland Ry., Lt. & P. Co. Fruitvale Power Plant	Purchased	2 G. E. turbo generators, 5,000 kw	13,200 Volts a. c., 3 φ, 25 ~		2	1/0	Copper	3' 0" Hor.				Trolley poles	13,200 v. a. c., 3 φ, 60 ~ 13,200 v. a. c., 3 φ, 25 ~	3	Motor generator Converter												1,500 v. d. c. 1,200 v. d. c.										Catenary Single catenary
[illegible]	[illegible]				127	129.5	1.5	131		Washington Water Power Plant		4 Hydro turbo generators, 3,000 kw	2,200 Volts a. c., 3 φ, 60 ~			#2	Copper						45,000 v. a. c., 1 φ, 25 ~	15	Transformer			O. I., S. C.	375 k.v.a.	45,000:6,600							6,600 a. c., 1 φ, 25 ~										Single catenary
[illegible]	[illegible]			Mar. 1908	22			45		Mt. Whitney Power Co					2	#4	Copper		120			Trolley poles	11,000 v. a. c., 1 φ, 15 ~	4	Transformer		13 12	O. I., S. C. O. I., W. C.	300 k.v.a.	11,000:3,300							3,300 v. a. c., 1 φ, 15 ~								22	45	Single catenary
[illegible]	[illegible]		Tunnel and terminal	1919	10			30		Part of hydro-electric net work														6	Transformer									2 G. E.	1,200/2,400	1,500 kw	2,400 v. d. c.										Catenary

…ochelle-Stamford Stamford-Glen Brook Glen Brook-New Haven [9]Harlem River branch [10]Harlem River branch [11]New Canaan branch [12]Over voltage tap Main line [15]White Plains branch [16]Full field [17]Shunted field [18]Without heating equipment [19]At 500 volts

IVES							Rating—T	
			Motors				Hourly	
ype of heostat	No.	Type	General Design	H. P. Each	Gear Ratio	Ventilation	Lbs.	H
....	4	G. E.	Series, d.c.	....	......	......	......	7
....	4	G. E.	Series, d.c.	....	......	......	......	8
....	4	G. E.	Series, d.c., com. pole.	....	......	......	25.000	1,1
....	4	West 403	....	....	22 : 91	Forced	23,000	..
....	......	....	....	....	......	......	......	..
....	......	....	Series, d.c., com. pole.	....	......	......	30,600	1,2
....	......	....	....	....	......	......	20,200	1,2
....	......	....	....	....	......	......	......	..
....	......	....	Series, d.c., com. pole.	....	......	......	45,200	3,4
....	......	....	Series, d.c., com. pole.	....	......	......	84,500	3,4
Grid	......	....	....	....	......	......	66,000	..
....	......	....	....	....	......	......	57,000	
....	......	....	Series, d.c.	....	......	......	46.000	3,2
....	......	....	....	....	......	......	.....	..
....	......	....	....	....	......	......	......	..
....	6	West 137	Series Comp., a.c...	....	16 : 85	Forced	52,000	..
....	......	....	....	...	......	......	......	..
....	......	....	$3\ \phi$ induction.....	....	......	......	38,000	1.5
....	......	....	....	....	......	......	......	..
....	......	....	....	....	......	......	......	..
....	......	....	Series, d.c., com. pole.	....	......	......	35,000	1,1
....	......	....	Series, d.c., com. pole.	....	......	......	34,000	1,1
....	......	....	Series, d.c.	....	......	......	21,500	2,2
....	......	....	Series, d.c.	....	......	......	17,200	2,3
....	......	....	Series, d.c.	....	......	......	20,500	2,6
....	......	....	Series, d.c.	....	......	......	20,500	2,6
....	......	....	....	....	......	......	......	..
Grid	4	West 130	....	....	......	Forced	9,700	..
Grid	8(4 twin)	West 409 A	....	....	22 : 92	Forced	17,700	.
Grid	2	West 406	....	....	......	Forced	15,750	..
Grid	4	West 403	....	....	34 : 79	Forced	13,200	.
Grid	4	West 403 B	....	....	34 : 79	Forced	13,200	..
....	4	West 410	....	....	17 : 101	Forced	23,200	.
Grid	4 twin	West 409	....	....	22 : 92	Forced	17,700	.
....	4 twin	West 409 C	....	....	22 : 92	Forced	17,700	.
....	4 twin	West 409 C	....	....	17 : 97	Forced	24,200	
....	4	West 410	....	....	17 : 101	Forced	23,200	.
....	4	West 410	....	....	17 : 101	Forced	23,200	
Grid	6 twin	West 409 C 2	....	....	27 : 87	Forced	21,000	..
....	4	West 410	....	....	17 : 101	Forced	23,200	.
Liquid	8	West 450 A 3ϕ	....	....	18 : 85	Forced	78,000	.
....	......	....	....	....	......	......	30,000	
....	......	....	....	....	......	......	......	.
Grid	2 2	West 103 West 129	....	....	......	Forced	15,000	.
Grid	2	West 315	....	....	......	Natural	[15]35,000 [16]22,200	.
Grid	2	West 315 A	....	....	......	Natural	[15]33,000 [16]21,000	.
Liquid	4	West 451 $3\ \phi$	....	....	21 : 106	Forced	88,000	
Grid	4	West 308 D3	....	....	16 : 57	Forced	20,400	.
Grid	4	West 308 D3	....	....	16 : 57	Forced	21,500	.
Grid	4	West 133	....	....	15 : 74	Forced	13,600	.
Grid	4	West 151	....	....	17 : 79	Forced	23,000	.
Grid	4	West 121 A	....	....	16 : 59	Natural	7,800	.
Grid	4	West 301 D2	....	....	17 : 60	Forced	16.000	.
....	4	West 132 A	....	....	17 : 66	Forced	11,600	.
44	......	....	Series, d.c., com. pole.		......	......	20,200	

DATA ON HEAVY ELECTRIC TRACTION IN UNITED STATES AND CANADA.

POWER DISTRIBUTION — Overhead Construction

Locomotives No.	Contact wire	Height Above Rail Max.	Min.	Type of Pole	Spacing	Average Distance between Anchor Bridges	Method of Returning Current	Feeders Positive	Feeders Negative	Track Bonds
7 West				Steel Bridges	150'		Rails			
8 G.E.	2-4/0 main 1-4/0 siding			Wood			Rails		1—4/0	250,000 c.m.
	3/0	21'	18'		120'		Rails			
3 West dbl.		22'		Steel Bridges Brackets	250' 12'					300,000 c.m.
41 West				Steel Bridges Steel ( )	300' 300'		3rd wire	New Roch. Woodlawn 2 4/0, 2 2/0 New Roch. Stanford 4—4/0		4/0 Flexible
1 West.				Steel Bridges	300'		3rd wire	4—4/0		
1 West				Steel	300'		3rd wire	4—4/0		
1 West				Steel Bridges	300'		3rd wire	4—4/0		
1 West				Wood				4—4/0		
1 West				Steel Bridge Steel Bridge Steel Bridge	300' 300' 300'		3rd wire 3rd wire 3rd wire	4 4/0 2 4/0 1 4/0 22,000 v 1 4/0 11,000 v		Pin term.
12 West		16'		Steel Bridges	300'		Rails			Equivalent 275" rd.
				Wood	150'		Rails			4/0 welded
1 West.							Rails			
1 West				Tubular Steel	300'	5 miles				
4 West				Cedar Steel Bridges	150'			Aluminum 336,420 c.m. 636,000 c.m.		
6 West.				Wood	150'					
1 West.		22'		Redwood	150'		Rails			

LOCOMOTIVES

No.	Series Numbers	Year in	Service Class	A.C. or D.C.	Classification Wheels Weights Motors	Voltage	Phase	Cycles	Type by wheels	Drivers No.	Drivers Diam.	Truck wheels No.	Truck wheels Diam.	Drive
3 G.E.				D.C.	1440-E 122 4 A&B 70	600			0-4-4-0	8				Gearless
5 G.E.				D.C.	080-E 160 4 GE 65 600	600			0-8-0	8				Geared
4 G.E.				D.C.	0440-E 200 4 GE 209-600	600			0-4-4-0	8				Twin geared
7 West	5000 to 5006	1911 to 1918	Pass. and freight	A.C.		11,000	1	25	2-4-0-0-4-2	8	63"	4	42"	Quill gears
26 G.E.			Freight	D.C.	0440-E 160 4 GE 229 1,200	2,400			0-4-4-0	8				Twin geared
2 G.E.			Passenger	D.C.	0440-E 160 4 GE 229 1,200	2,400			0-4-4-0	8				
3 G.E.			Switching	D.C.	0440-E 80 2 GE 229 1,200	2,400			0-4-4-0	8				
14 G.E.				D.C.	444444-E 601 8 GE 253 1,500 3,000	3,000			4-4-4-4-4-4	8				Twin geared
30 G.E.				D.C.	444444-E 576 8 GE 253 1,500 3,000	3,000			4-4-4-4-4-4	8				Twin geared
10 West	10300 to 10309	1920	Passenger	D.C.		3,000			4-6-2-2-6-4	12	68"	12	36"	Twin geared quill
8 G.E.					6886-E 530 12 GE 1,000 3,000	3,000			6-8-8-6					Gearless bi-polar
3 West dbl.	2665 to 2669	1908	Pass. and freight			3,300	1	25	0-6-0-0-6-0	12	62"			Gears, twin
4 G.E.					0440-E 230 4 GE 1,500									Twin geared
6 G.E.				D.C.	0440-E 200 4 GE 209-600	600			0-4-4-0	8				Twin geared
4 G.E.				D.C.	0440-E 240 4 GE 209 600	600			0-4-4-0	8				Twin geared
						600			4-8-4	8				Gearless bi-polar
						600			4-4-4-4	16				Gearless bi-polar
						600			4-4-4-4	16				Gearless bi-polar
10 G.E.				D.C.	4444-E 250 8 GE 91 600	600			4-4-4-4	16				Gearless bi-polar
41 West	01 to 040	1907	Passenger	Both		600 D.C. 11,000 A.C.	1	25	2-4-4-2	8	62"	4	33"	Quill, gearless
1 West.	069	1910	Pass. and freight	Both		600 D.C. 11,000 A.C.	1	25	2-8-2	8	63"	4	36"	Quill, gears
1 West	070	1910	Frt. and switching	Both		600 D.C. 11,000 A.C.	1	25	2-4-4-2	8	57"	4	36"	Side rod
1 West	071	1910	Pass. and fast frt.	Both		600 D.C. 11,000 A.C.	1	25	2-4-4-2	8	63"	4	42"	Quill, gears
1 West	072	1911	Pass. and fast frt.	Both		600 D.C. 11,000 A.C.	1	25	2-4-4-2	8	63"	4	42"	Quill, gears
1 West	0200	1911	Switching	A.C.		11,000 A.C.	1	25	0-4-4-0	8	63"			Quill, gears
3 West.	073 to 075	1912	Pass. and freight	Both		600 D.C. 11,000 A.C.	1	25	2-4-4-2	8	63"	4	36"	Quill, gears
34 West	076 to 096 099 to 0111	1912	Pass. and freight	A.C.		11,000 A.C.	1	25	2-4-4-2	8	63"	4	36"	Quill, gears
2 West	097 to 098	1912	Freight	A.C.		11,000 A.C.	1	25	2-4-4-2	8	63"	4	36"	Quill, gears
13 West.	0201 to 0214	1912	Switching	A.C.		11,000 A.C.	1	25	0-4-4-0	8	63"			Quill, gears
1 West	0215	1913	Switching	A.C.		11,000 A.C.	1	25	0-4-4-0	8	63"			Quill, gears
5 West	0300 to 0304	1919	Passenger	Both		600 D.C. 11,000 A.C.	1	25	2-6-2-2-6-2	12	63"	8	36"	Quill, gears
1 West	301	1912	Switching	A.C.		11,000 A.C.	1	25	0-4-0+0-4-0	8	63"			Quill, gears
12 West		1915	Freight	A.C.		11,000 A.C.	1	25	2-4-4-2+2-4-4-2	16	62"	8	36"	Gears and side rods
1 West.	1900	1906	Switching	D.C.		600 D.C.			0-4-0+0-4-0	8	56"			Axle mounted, gearless
West	3998 3999	1910	Passenger	D.C.		600 D.C.			4-4-0+0-4-4	8	68"	8	36"	Side rod
31 West	3976 3997 4000 4008	1910	Passenger	D.C.		600 D.C.			4-4-0+0-4-4	8	72"	8	36"	Side rod
1 West	3931 F11	1917	Freight	A.C.		11,000 A.C.	1	25	2-6-0+0-6-2	12	7?"	4	36"	Gears and side rods
4 West	1612 1615 1601 1610	1916	Freight	D.C.		600 1,200			0-4-0 swivel trucks	8	38½"			Gears
15 West	100 102 200 204	1912 1913	Freight	D.C.		2,600 1,200 3,600 1,500			0-4-0 swivel trucks	8	36½"			Gears
6 West.	M1 M6	1906	Freight	Both		600 D.C. 6,600 A.C.	1	25	0-4-0 swivel trucks	8	38"			Gears
8 West	M7 M14	1907 1910	Freight	Both		600 D.C. 6,600 A.C.	1	25	0-4-0 swivel trucks	8	50"			Gears
1 West	M99	1907	Freight	D.C.		600			0-4-0 swivel trucks	8	33"			Gears
1 West	502	1912	Freight	D.C.		600			0-4-0 swivel trucks	8	37½"			Gears
1 West.	A1		Freight	A.C.		3,300	1	15	0-4-0 swivel trucks	8	36"			Gears
4 G.E.					0440-E 166 4 GE 294 1,200									Twin geared

LOCOMOTIVES (continued) — Cab, Wheel Base, Weights, Current Collectors

No.	Cab No.	Length	Width	Height	Wheel Base Rigid	Wheel Base Total	Tractive Effort Thru	Mech. Parts	Equipment	Total	On Drivers	On Truck Wheels	% on Driver	3rd Rail Shoes	Trolley Wheel	Pantagraph
3 G.E.													100			
5 G.E.													100			
4 G.E.													100			
7 West	1 (Box)	48' 5"	10' 3"	14' 5"	7' 0"	38' 6"	Trucks	141,800	118,200	260,000	[illegible]	56,000	78.5			
26 G.E.													106			
2 G.E.													100			
14 G.E.													79			
30 G.E.													78			
10 West	1 (Box)	88' 7"	10' 0"	17' 0"	16' 9"	79' 10"	Trucks	280,000	270,000	550,000	336,000	214,000	61			
8 G.E.													86			
3 West dbl.	2 (Box)	58' 11"	9' 8"	15' 3"	16' 0"	45' 5½"	Trucks	147,300	116,700	264,000	264,000		100			
4 G.E.													100			
6 G.E.													100			
4 G.E.													100			
													61.7			
													100			
													100			
10 G.E.													100			
41 West	1 (Box)	37' 7½"	10' 2"	14' 3"	8' 0"	30' 9"	Cab	105,000	112,600	217,600	167,600	50,000	77	4		2 A.C., 1 D.C.
1 West.	1 (Box)	46' 8"	10' 3"	14' 2"	11' 0"	39' 0"	Trucks	111,500	120,500	232,000	176,000	56,000	76	4		2 A.C., 1 D.C.
1 West	2 (Box)	52' 0"	10' 3"	14' 3"	8' 0"	43' 6"	Trucks	138,000	132,000	270,000	192,000	78,000	71	4		2 A.C., 1 D.C.
1 West	1 (Box)	48' 0"	10' 3"	14' 2"	7' 0"	38' 6"	Trucks	151,000	129,000	280,000	187,000	93,600	67	4		2 A.C., 1 D.C.
1 West	1 (Box)	48' 0"	10' 3"	14' 2"	7' 0"	38' 6"	Trucks	120,000	128,000	248,000	184,000	64,000	74	4		2 A.C., 1 D.C.
1 West	1 (Steeple)	37' 0"	10' 3"	14' 2"	7' 0"	23' 6"	Trucks	79,700	78,300	158,000	158,000		100			1
3 West.	1 (Box)	[illegible]	10' 3"	14' 3"	8' 0"	40' 6"	Trucks	123,900	115,100	[illegible]	[illegible]	57,900	76	4		2 A.C., 1 D.C.
34 West	1 (Box)	50' 1"	10' 3"	14' 3"	8' 0"	40' 6"	Trucks	121,400	98,600	[illegible]	165,000	55,000	75			
2 West	1 (Box)	50' 0"	10' 3"	14' 0"	8' 0"	40' 6"	Trucks	121,400	98,600	220,000	165,000	55,000	75			
13 West.	1 (Steeple)	37' 6"	10' 3"	14' 2"	7' 0"	23' 6"	Trucks	83,400	75,800	159,200	159,200		100			1
1 West	1 (Steeple)	37' 6"	10' 3"	14' 2"	7' 0"	23' 6"	Trucks	83,500	71,200	154,700	154,000		100			1
5 West	1 (Box)	69' 0"		14' 2"	14' 3"	59' 6"	Truck	171,500	176,500	348,000	[illegible]	116,000	67	4		2 A.C., 1 D.C.
1 West	1 (Steeple)	37' 6"	10' 0"	14' 2"	7' 0"	23' 6"	Trucks	83,400	75,800	159,200	159,200		100			1
12 West	1 (Box)	105' 8"	11' 6½"	16' 0"	11' 6"	94' 10"	Trucks	[illegible]	219,000	540,000	448,000	92,000	83			4
1 West.	1 (Box)	[illegible]	10' 0"	15' 0"	8' 6"	26' 1"	Trucks			135,140	135,140		100	4		
West	2	64' 11"	10' 5½"	14' 8½"	7' 2"	55' 11"	Trucks	205,000	127,000	332,000				4		3 D.C.
31 West	2	64' 11"	10' 8½"	14' 8½"	7' 2"	55' 11"	Trucks	193,000	119,000	312,000	205,000	107,000	66	4		2 D.C.
1 West	1	76' 6½"	10' 1"	15' 6"	13' 4"	63' 11"	Truck	[illegible]	[illegible]	516,000	439,000	77,000	85			
4 West	1 (Steeple)	35' 0"	[illegible]	13' 11"	7' 4"	25' 0"	Cab	81,000	44,300	125,300	125,300		100			1
15 West	1 (Steeple)	35' 0"	10' 0"	13' 11"	7' 4"	25' 6"	Cab	[illegible]	45,050	[illegible]	[illegible]		100			
6 West.	1 (Box)	25' 0½"	9' 6"	[illegible]	7' 4"	21' 7"	Cab	51,700	48,300	100,000	100,000		100			
8 West	1 (Box)	38' 5"	9' 7½"	12' 2"	9' 6"	24' 10"	Cab	75,600	68,400	144,000	144,000		100			
1 West	1 (Box)		9' 6"	11' 6½"	6' 4"	20' 1"	Cab	51,480	23,520	75,000	75,000		100	1		
1 West	1 (Steeple)		9' 5"		6' 8"	[illegible]	Cab	[illegible]	30,250	99,500	99,500		100	1		
1 West.	1 (Box)	32' 2"	9' 6"		7' 4"	21' 1"	Cab	[illegible]	39,060	94,300	94,300		100			1
4 G.E.													100			

LOCOMOTIVES (continued) — Control, Motors, Rating

No.	Control Type	Regenerative	Transformer	Type of Rheostat	Motors No.	Motors Type	General Design	Gear Ratio	Ventilation	Hourly Lbs.	Hourly Hp.	Continuous Lbs.	Continuous Hp.	Max. Lbs.	Per cent coef. adhesion	Speed at rating Hourly	Speed at rating Continuous	Speed, Max. Safe	Total hp. at rating Hourly	Total hp. at rating Continuous
3 G.E.					4	G.E.	Series, d.c.				720									
5 G.E.					4	G.E.	Series, d.c.				800									
4 G.E.					4	G.E.	Series, d.c., com. pole			25,000	1,120	13,000	660							
7 West	West H.B.	No	A.B.		4	West 403		[illegible]:91	Forced	23,000		20,500								
26 G.E.							Series, d.c., com. pole			30,000	1,280	25,000								
2 G.E.										20,200	1,280	16,200								
14 G.E.		Yes					Series, d.c., com. pole			45,200	3,440	38,000	3,000	119,000						
30 G.E.		Yes					Series, d.c., com. pole			84,500	3,440	70,700	3,000	135,000	30					
10 West	West H.B., dbl. end	Yes		Grid						66,000 57,000		49,000 40,800		112,000	33					
8 G.E.							Series, d.c.			46,000	3,240	42,000	2,760	115,000	25					
3 West dbl.	West H.B., dbl. end	No	A.B.		6	West 137	Series Comp., a.c.	16:85	Forced	52,000		37,000		88,000	33					
4 G.E.							3 φ induction			38,000	1,500	34,800	1,400	69,000	30					
6 G.E.							Series, d.c., com. pole			35,000	1,120	17,600	660	60,000						
4 G.E.							Series, d.c., com. pole			33,000	1,120	17,600	660	60,000						
							Series, d.c.			21,500	2,200	5,000	800	42,600						
							Series, d.c.			17,200	2,340	11,400	1,760	67,200						
							Series, d.c.			20,500	2,640	14,000	2,000	75,000						
10 G.E.							Series, d.c.			20,500	2,640	14,000	2,000	75,000						
41 West	West H.B., dbl. end	No	2 A.B.	Grid	4	West 130			Forced	9,700		6,400		20,000	12	55	66	88	1,420	1,125
1 West.	West H.B., dbl. end	No	A.B.	Grid	8 (4 twin)	West 409 A		22:9?	Forced	17,700		12,200		40,000	23	36	41.8	54	1,700	1,350
1 West	West H.B., dbl. end	No	A.B.	Grid	2	West 406			Forced	15,750		12,300		40,000	21	30	35.6	61		
1 West	West H.B., dbl. end	No	A.B.	Grid	4	West 403		34:79	Forced	13,200		11,800		4?,000	21	46	48	55		
1 West	West H.B., dbl. end	No	A.B.	Grid	4	West 403 B		34:79	Forced	13,200		11,800		40,000	22	46	48	55		
1 West	West H.B., dbl. end	No	A.B.		4	West 410		17:101	Forced	23,200		14,800		45,000	28	12.1	14.8	25		
3 West.	West H.B., dbl. end	No	A.B.	Grid	4 twin	West 409		[illegible]	Forced	17,700		12,200		40,000	22	36	41.8	54		
34 West	West H.B., dbl. end	No	A.B.		4 twin	West 409 C		[illegible]	Forced	17,700		12,200		40,000	21	36	41.8	54		
2 West	West H.B., dbl. end	No	A.B.		4 twin	West 409 C		17:97	Forced	24,200		16,700		55,000	33	26.4	30.4	39.5		
13 West.	West H.B., dbl. end	No	A.B.		4	West 410		17:101	Forced	23,200		14,800		45,000	28	12.1	14.8	25		
1 West	West H.B., dbl. end	No	A.B.		4	West 410		17:101	Forced	23,200		14,800		45,000	29	12.1	14.8	25		
5 West	West H.B.	No	A.B.	Grid	6 twin	West 409 A 2		57:87	Forced	21,000		14,500		47,500	21	25.6	32.5	70		
1 West	West H.B.	No	A.B.		4	West 410		17:101	Forced	23,200		14,800		45,000	25	12.1	14.8	25	750	57
12 West	West H.B. split phase	Yes	A.B.	Liquid	8	West 450 A		18:88	Forced	78,000 39,000		62,000 35,600		112,000	25	14.3 28.6	14.3 28.6	35		
1 West.	West H.B.			Grid	1-2	West 103 J			Forced	15,000		[illegible]		38,000			38.8			
West	West H.B., dbl. end	No		Grid	2	West 318			Natural					83,500				76		
31 West	West H.B., dbl. end	No		Grid	2	West 317 A			Natural					73,100	38			80		
1 West	West H.B. split phase	Yes	A.B.	Liquid	4	West 451 A		[illegible]:106	Forced	88,000		73,000		[illegible]			20.5	36	4,800	
4 West	West H.L., dbl. end	No		Grid	4	West 308 D3		16:57	Forced	20,400		10,500		40,000	3?	18.5		38		
15 West	West H.L., dbl. end	No		Grid	4	West 308 D3		16:57	Forced	21,500		11,100		42,000	31	17.8	22	40	1,300	
6 West.	West H.B., dbl. end	No	O.L.S.C.	Grid	4	West 133		15:71	Forced	13,000		6,500		28,000	28		22	30	880	580
8 West	West H.B., dbl. end	No	O.L.S.C.	Grid	4	West 151		17:79	Forced	23,000		14,700		4?,000	31	11.4	14.6		700	575
1 West	West H.L., dbl. end	No		Grid	4	West 121 A		16:59	Natural	7,800		4,000		15,000	21	15.3	21.8	34		
1 West	West H.L., dbl. end	No		Grid	4	West 301 D		17:60	Forced	16,000		9,200		24,875	25				400	280
1 West.	West H.B., dbl. end	No	A.B.		4	West 132 A		17:66	Forced	[illegible]		5,000		23,325	25	17.3			540	360
4 G.E.							Series, d.c., com. pole			30,200	1,280	16,900	1,000	40,800	36					

Report on Train Lighting Equipment and Practice

Committee's Report Includes Slight Modifications from That Presented at Semi-Annual Meeting

Committee

L. S. Billau (chairman), assistant electrical engineer, Baltimore & Ohio.
F. J. Hill, chief electrician, car department, Michigan Central.
E. W. Jansen, electrical engineer, Illinois Central.
E. Lunn, chief electrician, Pullman Company.
A. McGary, chief electrician, New York Central.
C. H. Quinn, chief electrical engineer, Norfolk & Western.
J. R. Sloan, chief electrician, Central region, Pennsylvania System.
A. E. Voight, car lighting engineer, Atchison, Topeka & Santa Fe.
E. Wanamaker, electrical engineer, Chicago, Rock Island & Pacific.

YOUR committee submits the following report: (1) specification for axle generators; (2) increased clearances in battery boxes.

At the June meeting a full report on the proposed specification for axle generator lighting equipment was presented. Some minor changes were adopted by the association and therefore the specification is being resubmitted in its corrected form.

The corresponding committee of Section III, Mechanical, of the American Railroad Association, is also investigating the subject of axle generator suspension, and arrangements were, therefore, made to hold joint meetings of the two committees. Representatives of the axle generator manufacturers were invited to attend the meetings of the committee and considerable correspondence was conducted with them and also with the manufacturers of ball bearings.

Before presenting the result of the work of the committee in the shape of a specification, it seems desirable to discuss, in more or less detail, the various features that were considered. This discussion will serve to explain why certain items which form a part of a complete specification were omitted; and why items that were included were finally decided upon.

Generator Frame Material

Generator frames may be made of rolled or cast steel or of cast iron. Cast iron is lower in cost per pound than steel, but has a lower magnetic permeability, therefore requiring a greater weight to obtain the same electrical effect. From a service standpoint each material is acceptable and the decision which to use is really based on economic considerations; modified by the space requirements that must be observed. Where space is a factor, the frame should be of cast or rolled steel. Where space is not a factor, cast iron may be used.

Lugs on Generator Frame for Suspension, Belt Tension and Safety Device, Location and Size

Various attempts have been made to standardize these lugs, but all have failed, due principally to the variety of suspensions and belt-tension devices in use, caused by the differences in car body and truck design. Your committee, therefore, felt that it was useless to attempt to standardize this feature. However, the necessity of replacing axle generator frames, due to accident or wear, is a rare occurrence and therefore the standardizing of these lugs is comparatively unimportant, in so far as interchange between railroads is concerned.

Generators should be overhauled periodically and this work is generally done by the owning road. Such overhauling can best be done by removing the generator from the car and taking it into the shop. In order to avoid holding the car out of service it is desirable to be able to replace the generator removed with a generator that is known to be in good order. It is therefore an advantage to any road to have the location and size of the generator frame lugs identical on all axle generators of their ownership so that this exchange of generators can readily be made.

If a railroad will analyze the conditions as found on their own cars, your committee believes it possible, in most cases, to design the suspension and belt tension so as to permit the location and size of the necessary lugs on the axle generator being fixed, and all axle generator manufacturers can usually furnish generators having the lugs in the location desired. This procedure has already been followed by some roads with very good success.

With regard to safety lugs, the necessity of these, especially on body hung generators, is open to question. The mechanical engineers of many roads prefer to omit them and make the suspension lugs of such design that they are of more than sufficient strength for the duty required. Wear of the holes in the suspension lugs will result in improper alignment of the generator, causing a loss of belts and in time will necessitate scrapping the generator frame from considerations of safety. To prevent this wear it is good practice to bush the holes in the suspension lugs with a bushing properly secured in the lug.

While in no way related to the question of axle generator specifications, we desire at this time to call attention to a matter that should receive particular attention when considering the type of suspension. The question is that of clearance of the belt and belt-fasteners from any portion of the truck and car body, as the amount of clearance is a very important factor in determining the mileage obtained from the belt. Especial effort should be made to make this clearance, initially, as great as possible, so as to take care of wheel wear, brake rigging wear, spring deflection, etc. When proper allowance has been made for the effect of all factors which tend to alter the amount of the belt clearance and reduce it to a minimum, your committee feels that under such conditions of minimum belt clearance, the clearance from any part of the belt or belt-fastener to any part of the truck or car body should be at least ½ in. (See Proceedings A. R. E. E., page 159, Vol. 9, 1916.) The best belt conditions are obtained when both brake beam and truck end-sill come between the two runs of belt.

Armature Shafts Material

Armature shafts were formerly made of mild steel and trouble with these shafts breaking or bending at the pulley end was encountered. This trouble was probably due in some cases to the strain caused by excessive belt tension, in others to the shock of coupling or to torsion developed when the bearings seized. The use of ball bearings has practically eliminated the latter cause and at the same time has necessitated, in order to mount properly the bearing and permit its removal and reapplication, the use of a better grade of steel. It, therefore, seems desirable to specify the characteristics that a steel suitable for this purpose should possess.

Assembly of Armature

For years the armatures of axle generators were built with the laminations and end plates keyed directly to the armature shaft, a construction that necessitated scrapping the armature when the shaft was damaged. Modern armatures of all types of electrical machines have the laminations and end plates and also the commutator assembled on a quill and the quill is then keyed to the shaft. This construction permits the removal and replacement of the shaft.

Bearings

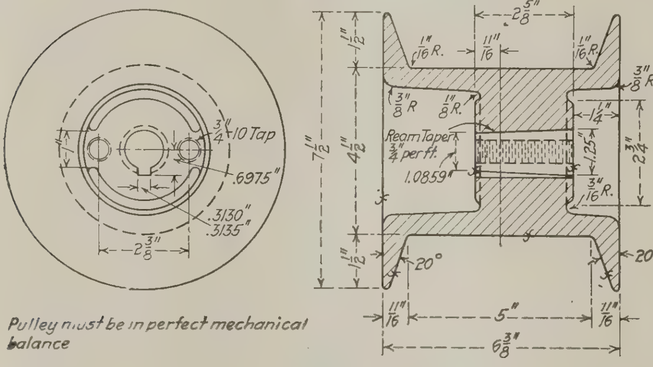
The sleeve bearings that were originally used on axle generators were a most prolific source of trouble, due to wearing, running hot and seizing. Also the bearings were not interchangeable, almost every make and type of generator requiring a different bearing. These conditions required that the bearings be frequently and carefully inspected, as excessive wear would permit the armature to drop and strike on the pole face, damaging both field and armatures. In order to guard against this condition and postpone the day on which it would be necessary to renew the bearings on account of legitimate wear, it was customary to design the generator with an air gap having a liberal mechanical clearance, which, of course, tended to increase the size of the generator and also the cost. Ball bearings seemed to offer a remedy for this trouble, inasmuch as they had been standardized by the manufacturers in a series of definite sizes, so that ball bearings of any given size, no matter by whom manufactured, were interchangeable and, due to the construction of the bearing, the clearance of the air gap could be reduced materially without danger to the armature striking on the pole faces.

The movement to standardize ball bearings was started at the time the use of ball bearings was first begun. After consultations with the ball bearing and axle generator manufacturers a series of sizes was selected and reported by the committee. (See Proceedings A. R. E. E., Page 87, Vol. 10, 1918.) Your committee now recommends that two additional sizes be added, as shown in the table on sizes of ball bearings, as given in the specification.

It is essential to obtain good service that ball bearings be not overloaded and also the manner in which the bearings are mounted is of great importance in determining the service to be obtained. Thus one bearing must approximately be fixed in position, while the other must have a longitudinal movement so that it can accommodate itself to the change in length of the armature shaft as these changes occur with varying temperatures. The load on a bearing is either radial, thrust, or a combination of the two. From the nature of the design the greater part of the radial load must be borne by the pulley bearing, and it is therefore customary, in order to equalize the load, to make the commutator end-bearing sustain the thrust.

It is also essential that a proper fit of the shaft in the bearing and of the bearing in the housing be obtained. If the shaft is too small or the housing either too large or too small, the bearing will not function as a bearing. If the shaft is too large the inner race of the bearing will probably crack when the attempt is made to mount the bearing on the shaft.

In the past such terms as "sucking fit," "press fit," and "light drive fit," were used to describe the various kinds of fit desired, but these terms were not accurate and it seems best that certain dimensions with allowable tolerances be fixed. The question was therefore taken up with the ball bearing manufacturers and information obtained relative to the above, together with corresponding data concerning the bearings themselves.



Pulley must be in perfect mechanical balance

Fig. 1—A 4½ in. Pulley for Controlled Speed Generator

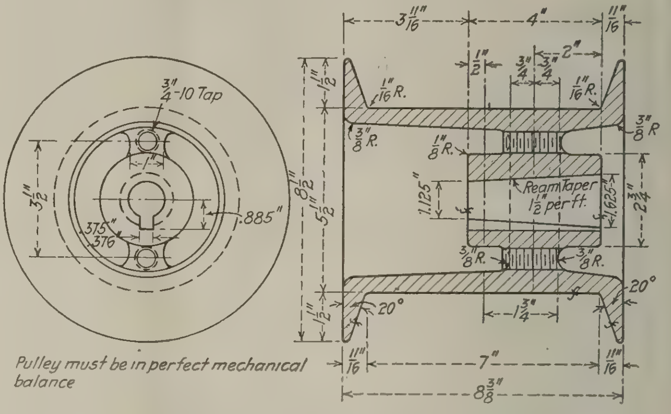
Grease Retainers

When sleeve bearings were used, oil was the lubricant employed, and this oil would travel along the shaft and into the frame, where it would become mixed with carbon dust and cause grounds; or become deposited on the commutator, causing the generator to fail to generate. With ball bearings, which in this service ordinarily use grease as a lubricant, the same trouble is sometimes experienced during very warm weather, if an excessive amount of grease is placed in the bearing and some provision is not made to retain it. This trouble can be prevented if grooves are machined in the bore of the end housings and felt washers, fitting the shaft snugly, are applied to the inner side of the commutator end housing and to both sides of the pulley end housing.

Pulleys, Pulley Nuts and Keys

In past years your committee has made recommendations relative to armature pulleys, pulley nuts and keys. (See Proceedings A. R. E. E., Page 85, Vol. 10, 1918.) The idea on which these recommendations were based was to standardize fully the armature pulley so that renewals could be promptly made to foreign cars, and three sizes, *i. e.*, 5½ in., 8 in. and 11 in. diameter, were selected. It now appears advisable, in view of the advent of the "controlled speed" axle generator and what will later be said on the subject of "capacity" and "minimum full load speed," to increase the number of pulleys as determined by the diameter, while retaining the other dimensions, such as bore, taper, etc., which will enable one to renew a broken pulley even though the pulley applied be not of proper diameter to obtain the minimum full load train speed for which the generator was intended.

Armature pulleys have been made of pressed steel, cast steel, malleable iron, cast iron and various composite structures. General experience indicates that of these various materials cast iron, everything considered, is the most suitable for the work, and that much of the trouble that has been experienced with cast iron pulleys has been due to the design.



Pulley must be in perfect mechanical balance

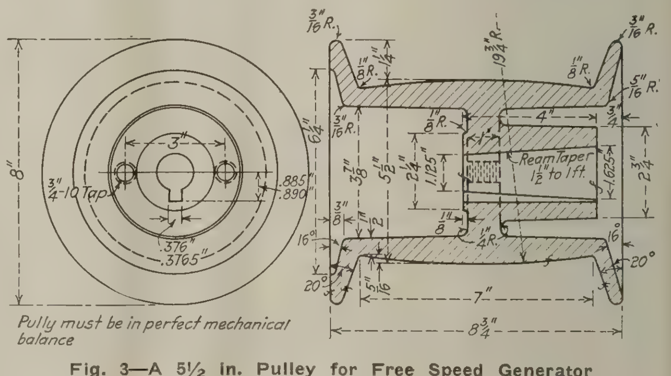
Fig. 2—A 5½ In. Pulley for Controlled Speed Generator

Your committee has therefore prepared designs for cast iron pulleys in the following sizes:

Controlled speed generators Diameter of pulley—inches	Free speed generators Diameter of pulleys—inches
4½	5½
5½	6½
...	8
...	10

The designs are such that it is hoped that the trouble, *i. e.*, broken flanges, will be at least partially overcome. These designs are shown on Figs. 1 and 2 for controlled speed generators and Figs. 3 to 6, inclusive, for the free speed generators.

Pulleys of these designs for freed speed type of generators are interchangeable for all makes and sizes of generators of the general type having the pulley fit shown in Fig. 1, Page 85, Vol. 10, 1918, for axle generator having ball bearings. The size of the armature pulley that should be used in any given case will depend upon the maximum load, the minimum full load, speed desired, the pulley ratio, the maximum size pulley permissible and the belt clearances.



Pully must be in perfect mechanical balance

Fig. 3—A 5½ In. Pulley for Free Speed Generator

Field Coils

When field coils are constructed so that there are no means other than the outer layers of tape for holding the several turns fixed in their relation to one another, movement of the several turns results, due to the vibration occurring from service conditions. As the cotton insulation that is generally used will in time char, due to the heat generated by the operation of the generator, this movement will flake off the charred insulation and the turns will be short-circuited, or, in other words, the coil will be burned out. The vibration will in time similarly affect a similar coil insulated with Class "B" insulation. It is therefore important that the several turns and layers be so held that no relative movement can occur. This can be accomplished by impregnating the coils with an insulating compound which binds the several layers and burns into one solid mass, so that no relative movement can result. Therefore, your committee is of the opinion that field coils should be impregnated to conform with established practices of electrical manufacturers or thoroughly saturated by dipping process with insulating material and then baked.

Air Gap

The smaller the air gap, that is, the distance radially between the iron of the armature and the pole face, the less the reluctance of the magnetic circuit, and therefore the less the number of ampere turns which are required to energize the field. Decreasing the air gap therefore tends to reduce the size of the generators and also its first cost. The use of ball bearings permits the use of a small air gap, as little provision for wear is necessary. Experience has shown that, when using ball bearings, the mechanical clearance in the air gap will be sufficient, if it is possible to pass in a direction parallel to the shaft, at all points between the armature and the pole faces, an oval feeler ½ in. wide and 0.05 in. thick.

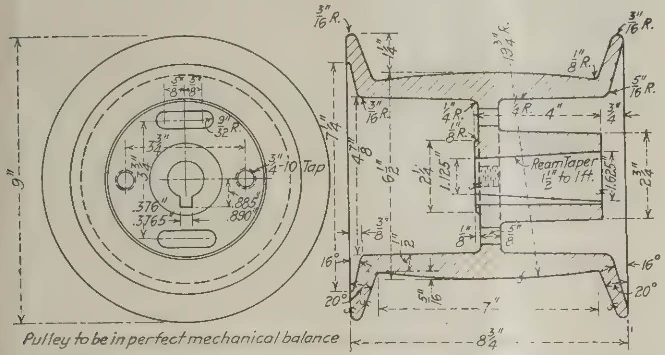


Fig. 4—A 6½ in. Pulley for Free Speed Generator

Regulators—Location of Holes for Supporting Bolts

The two Z-bars or other shapes by which the generator and lamp regulator panels are supported are, ordinarily, most conveniently placed in the regulator cabinet in a vertical position.

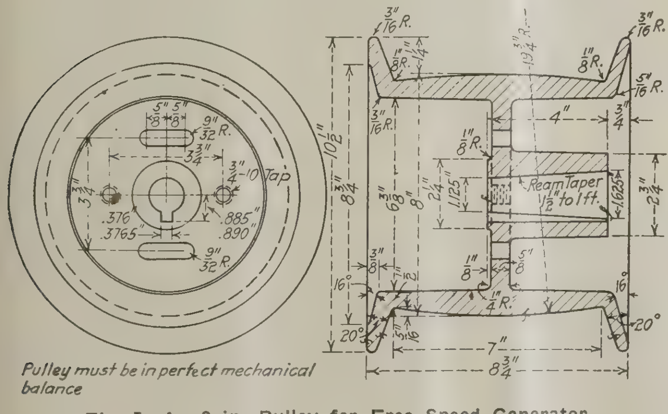


Fig. 5—An 8 in. Pulley for Free Speed Generator

Therefore, if the horizontal distance between the centers of the holes in the panels through which the supporting bolts pass is standardized, one location of these regulator supports may be employed which will tend to simplify the car construction. It is, of course, desirable that the vertical centers of the same holes be also standardized, but not so important as it is for the horizontal holes. Your committee investigated this matter and found the horizontal center of these holes varied from 13 to 14¾ in., while the vertical centers varied from 8 to 31 in.

By agreement with the axle generator manufacturers, the width of all panels, both generator and lamp regulator panels, has been made 16 in. and the horizontal distance between center of holes which are 7/16 in. in diameter has been made 14 in., they being placed 1 in. from each side and also 1 in. from each end of the panel.

In order to prevent the supporting frame work short-circuiting the wiring on the rear of the panels, it is frequently necessary to have clearance at this point. The corner bracket, used for this purpose, to be interchangeable and to make all panels interchangeable, should be designed so that the holes for the supporting bolts shall be the same size as the hole in the panel, *i. e.,* 7/16 in. and when mounted on the panel should have the same horizontal distance between centers, *i. e.,* 14 in.

Cutting in Speed and Maximum Speed

The r. p. m. of the armature shaft or the speed of the train in miles per hour at which the automatic switch closes, thus connecting the battery and load circuits to the generator, is known as the "cutting in speed." This speed is a function of the design of the generator. Roughly, this speed will be about 75 per cent of the minimum full load speed.

The maximum speed is that speed at which the generator may be operated without trouble, either of an electrical or mechanical nature, developing. The 36 in. diameter car wheel is generally used under passenger equipment cars and this wheel, when worn to the limit, is 33 in. in diameter. The maximum train speed permitted by the rules of most railroads is about 75 miles per hour. The rotative speed of a 33-in. wheel on a car traveling at the rate of 75 miles per hour is equal to the rotative speed of a 36-in. wheel on a car traveling at the rate of 81.8 miles per hour.

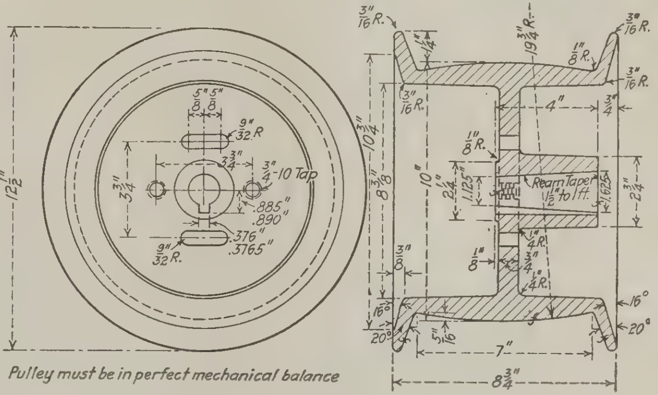


Fig. 6—A 10 in. Pulley for Free Speed Generator

Therefore, the armature must be built to be mechanically safe when the car, with the pulley ratio as intended and using a 33-in. wheel, is traveling at the rate of 75 miles per hour.

Owing to the manner in which free speed axle generators are ordinarily controlled, an increase in the armature speed necessitates a decrease in the field current. At high speeds, therefore, a very weak field is used, with resultant liability of vicious sparking at the brushes, due to the plane of commutation shifting on account of the change in the value of the ampere turns in the fields with respect to the ampere turns in the armature. However, excessive sparking may continue for some time and damage the generator, only to the extent of necessitating the turning of the commutator, but failure of the armature mechanically will result in the destruction of both fields and armature.

Minimum Full Load Speed

The minimum r. p. m. of the armature, or the minimum miles per hour of car travel at which the generator will carry full rated load, is known as the "minimum full load speed." It will be noted that the relative values of the two ways of expressing this speed will vary with the pulley ratio and size of wheel. This relation is shown on Figs. 7 to 10, inclusive.

The "minimum full load speed," expressed as r. p. m. of the armature, is a factor of prime importance in the design of the axle generator; a lower r. p. m. generally necessitating a larger generator. Until quite recent years, axle generators were purchased principally for use on cars operated in through service on the main line of railroads, where ordinarily the distance and therefore the time interval between stops was considerable, while the average rate of speed was comparatively high. Under these circumstances a minimum full load speed of approximately 25 miles per hour was low enough to give satisfactory operation. However, a point has lately been reached in equipping passenger cars with electric light that makes it necessary to consider the conditions which obtain when the cars to be lighted are operated in branch line or local service.

The operating conditions that are generally characteristic of branch line and local service are:

(a) A less distance between stops than is generally encountered on main lines, and therefore a less time interval between stops.

(b) A lower schedule speed, both average and maximum.

(c) A less total distance to traverse in a day.

Therefore, the actual time that the axle generator is in operation per day is generally less in branch line and local service than it is in main line service, and the percentage of the total elapsed time of the run that the train speed is above a given figure, is also less.

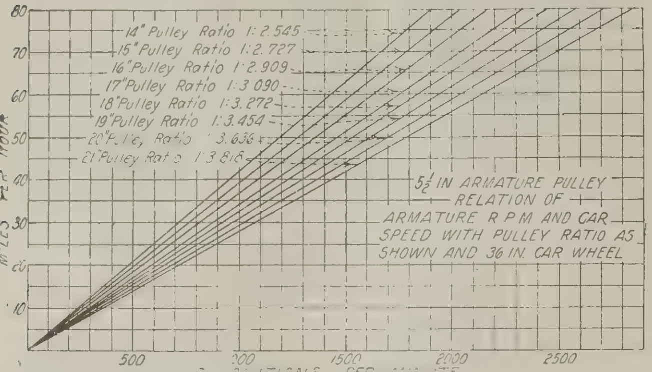


Fig. 7—Curves Showing Relation of Armature R.P.M. and Car Speed for a 5½ in. Armature Pulley

It is therefore apparent that an axle generator which will maintain the lighting of a car in main line service may give entirely unsatisfactory results when the car is operated in branch line or local service, but that a generator that will maintain the lighting in branch line and local service will also maintain the lighting in main line service. In other words, the generator with the low minimum full load speed will maintain the lighting in both classes of service.

As operating conditions may cause cars assigned to branch line or local service to be shifted to main line service and vice versa, it would seem desirable, from an operating point of view, to have all cars equipped with generators which will permit the car to be used wherever it may seem desirable. If generators with a given minimum full load speed will not satisfactorily maintain the lighting of the car, there are only two remedies in so far as the axle generator is concerned:

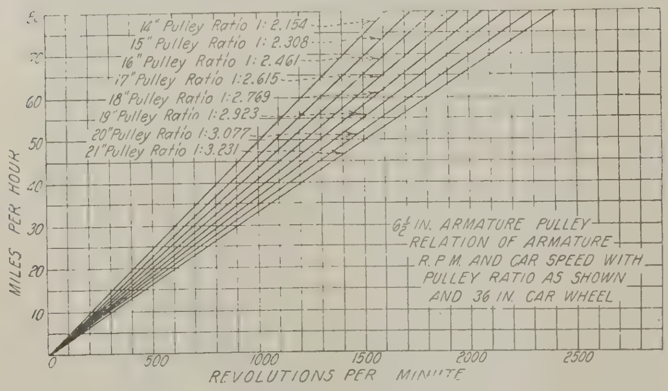


Fig. 8—Relation of Armature R.P.M. to Car Speed for a 6½ in. Armature Pulley

(a) Decrease the minimum full load speed so as to have the generator in action a greater proportion of the time.

(b) Increase the net ampere capacity of the generator.

Both courses result in an increase in the total ampere hour output of the generator and both will entail a generator of larger physical dimensions.

It is a comparatively simple matter to take a series of speed time curves, and from an inspection of them, determine a proper minimum full load speed, and then calculate the net ampere capacity required of the generator. It is a much more difficult problem to assume a new ampere capacity and determine the maximum possible value of the minimum full load speed. Typical speed time curves of branch line operation are shown on Fig. 11. The question is further discussed under the caption, "Net current capacity of axle generators."

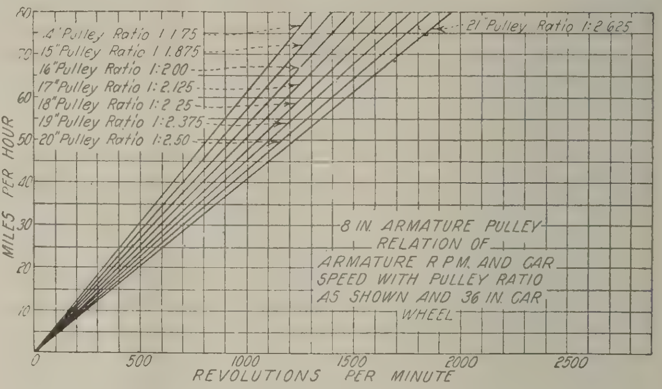


Fig. 9—Relation of Armature R.P.M. to Car Speed for an 8 in. Armature Pulley

Designation of Axle Generator Capacity

Heretofore it has been customary to refer to axle generators as having a certain kilowatt capacity. In view of the association in 1919 having adopted as recommended practice that the rating of axle generators shall be expressed in amperes, it appears preferable to refer to them hereafter as having a certain "net current capacity."

Net Current Capacity of Axle Generators

In determining the minimum net current capacity of an axle generator that will be required to maintain successfully the electric service on a certain run, consideration must be given to several conditions.

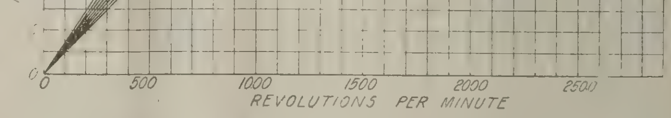


Fig. 10—Relation of Armature R.P.M. to Car Speed for a 10 in. Armature Pulley

The two factors which determine the minimum generator capacity are the amperes on battery discharge and the battery capacity, and these vary with:

(a) The size of the car, that is, the number and voltage of the lamps, fans, etc., installed on the car.

(b) The amperes required to operate the lamps, fans, etc., when the maximum number in service at any one time is turned on.

(c) The magnitude and duration of the various discharges of the battery and the time at which each occurs with respect to the full cycle of operation of the car.

(d) The speed time curve of the car for its full cycle of operation, taking into consideration the question of the relation of the time at which current will be required with respect to this speed time curve.

(e) Having decided upon the voltage of the battery, a study of conditions (a), (b) and (c) will determine the ampere hour capacity of the battery to be used; and the capacity determines the normal rate of charge and discharge of the battery.

(f) Conditions (c), (d) and (e) must then be studied to determine the net ampere capacity of the axle generator.

To do this a minimum full load speed must first be assumed. Then the generator, while running at this or higher speeds, must furnish all current required by the lamps, fans, etc., and in addition it must replace in the battery the ampere hours consumed when the speed is less than the assumed minimum speed plus additional ampere hours sufficient to compensate for the ampere hour efficiency or inherent losses of the battery.

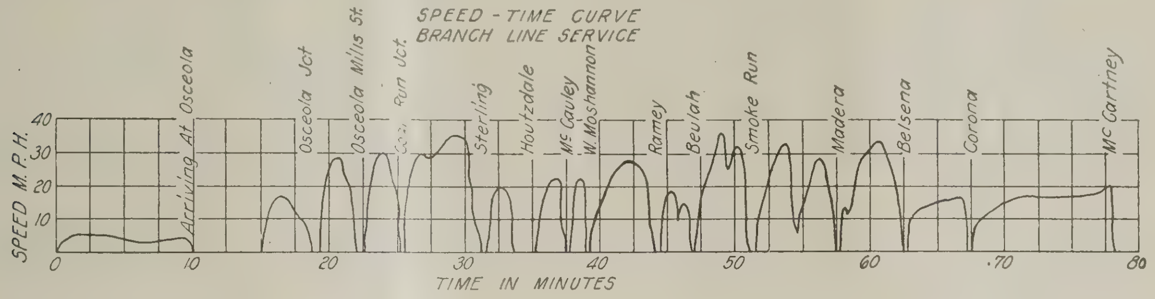


Fig. 11—Typical Speed Time Curves of Branch Line Operation

Of course, the higher the minimum full load speed is assumed, the greater the net current capacity of the generator must be, as in the same cycle of operation of the car it is in action a lesser time, while the ampere hour requirements may be and generally are increased. From the above it will be seen that to cover the entire field, *i. e.*, all classes of cars, kinds of service and character of runs, the calculated minimum net ampere capacity would probably vary with each possible combination. It should also be noted that, while a higher minimum full load speed in miles per hour entails a larger output in ampere hours, and ordinarily would require a generator of larger capacity, that is not necessarily so, and in fact the reverse may be the case. The reason for this is, that as yet, the question of the minimum armature r. p. m. at which the generator will carry the desired net amperes has not been considered.

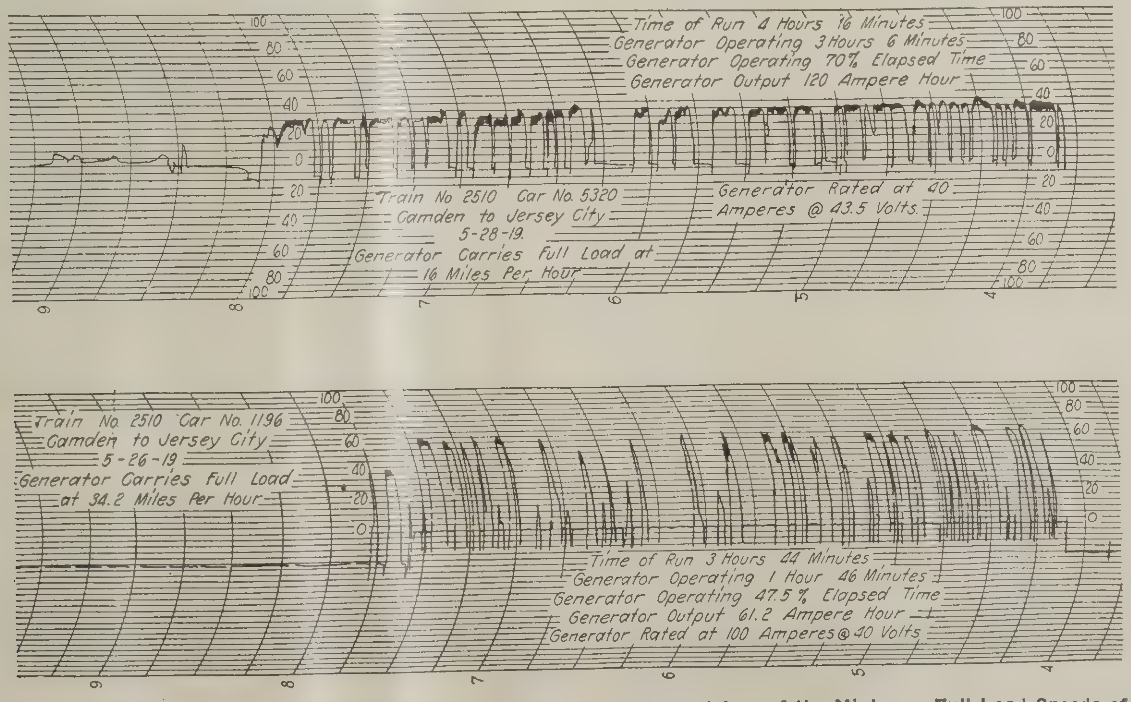


Fig. 12 (above) and 13—Curves Showing the Effect of Very Low and Very High Values of the Minimum Full Load Speeds of Generators Operating in the Same Train

Minimum Armature Speed

The minimum armature speed depends upon:

(a) The minimum train speed at which the generator must carry the desired net amperes.

(b) The diameter of the car wheel.

(c) The relative diameter of the axle and armature pulley, *i. e.*, the ratio of reduction.

When considering the minimum armature r. p. m. at which the net ampere capacity is to be generated and the ratio of reduction to be used, the question of the maximum armature r. p. m. must not be lost sight of, as otherwise, at high train speeds, the r. p. m. of the armature may be so great as to be dangerous. Consideration of the above indicates that for any given case a great number of solutions is possible, and that when all cases are considered the number of possible solutions of the minimum net ampere capacity is infinite.

When theory is reduced to practice, a number of factors, such as clearance, practical pulley ratios, belt strength, etc., operate to reduce greatly the number of practical solutions. Your committee considers that experience has demonstrated that the following combination will cover the entire field:

Class of service	Approximate maximum load demand	Ampere hour capacity of battery Min.	Ampere hour capacity of battery Max.	Ampere capacity of generator	Minimum full load speed M. P. H.
Official, sleeping, parlor, mail and dining cars having heavy lighting loads, or severe operating conditions..	50	350	600	100	26
Mail, dining cars, etc., where the lighting loads are not so heavy or the operating conditions so severe......	35	300	350	75	26
Coaches, passenger baggage cars, baggage cars under average operating conditions.	25	200	300	50	21
Same cars as next above operating in slow speed branch line or local service.......	25	150	225	50	16

It is, however, an open question as to how far to apply this table. The question should be determined by each railroad from a study of the conditions under which their cars must operate; giving full consideration to the first cost of equipment, value of stock to be carried for repair, etc.

For instance, if the conditions on any road are such that the majority of cars require, for successful lighting, an axle generator having a minimum full load speed of, say, 16 miles per hour, and conditions of operation are such that the cars are liable to be transferred from one class of service to another, it would seem desirable to make all generators of the one design, even though the first cost of some of the generators was greater than necessary. The advantage of no restrictions on the operating department in the manipulation of the cars and of having one type of generator and the decrease in the amount of repair parts to be carried in stock should outweigh the additional first cost.

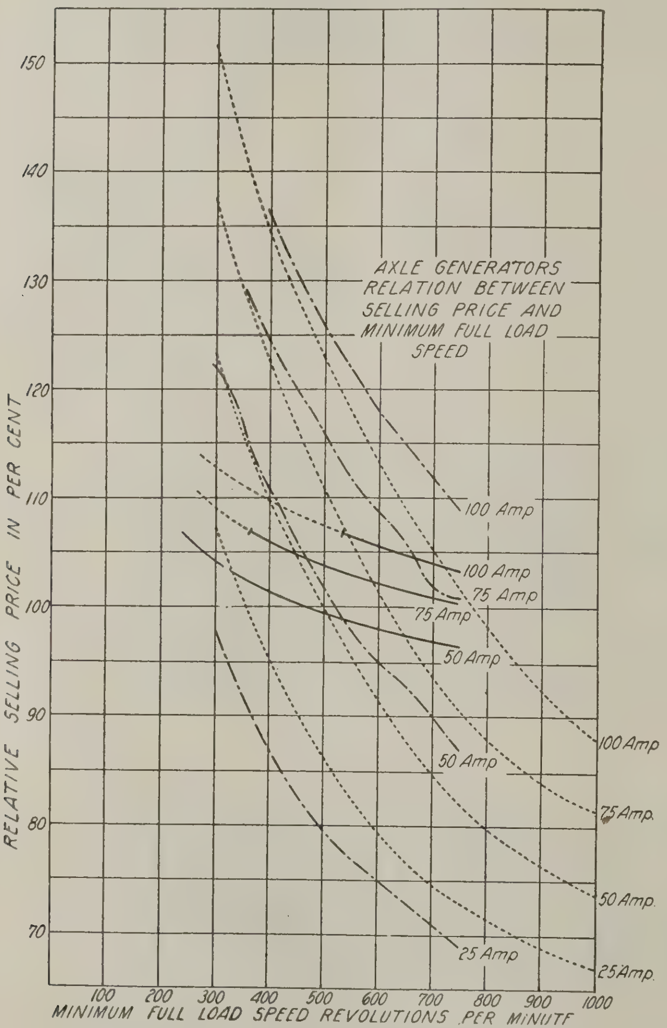


Fig. 14—Curves Showing Relation Between Selling Price and Minimum Full Load Speed of Axle Generators

On the other hand, if the cars are restricted to certain runs and if the requirements of the service indicate that a considerable number of cars requires generators having minimum full load speed of 21 miles per hour or both 21 and 26 miles per hour, it might be desirable to have generators of different minimum full load speed. As an aid in deciding the question, we attach time current curves, Figs. 12 and 13, showing the effect of very low and very high values of the minimum full load speeds of generators operating in the same train; and also curves showing the variation in cost price, Fig. 14, on a percentage basis, of complete axle generator equipment with respect to minimum full load speeds in r. p. m. of the armature shaft. In these latter curves the full lines represent one make of axle generator, the dotted lines another, etc. In each set of curves, the 50-ampere generator at a minimum full load speed of approximately 500 r. p. m., has been taken as 100 per cent cost price. It should be noted that the 100 per cent cost price in dollars for one make of generator bears no relation to the cost in dollars of any other make of generator.

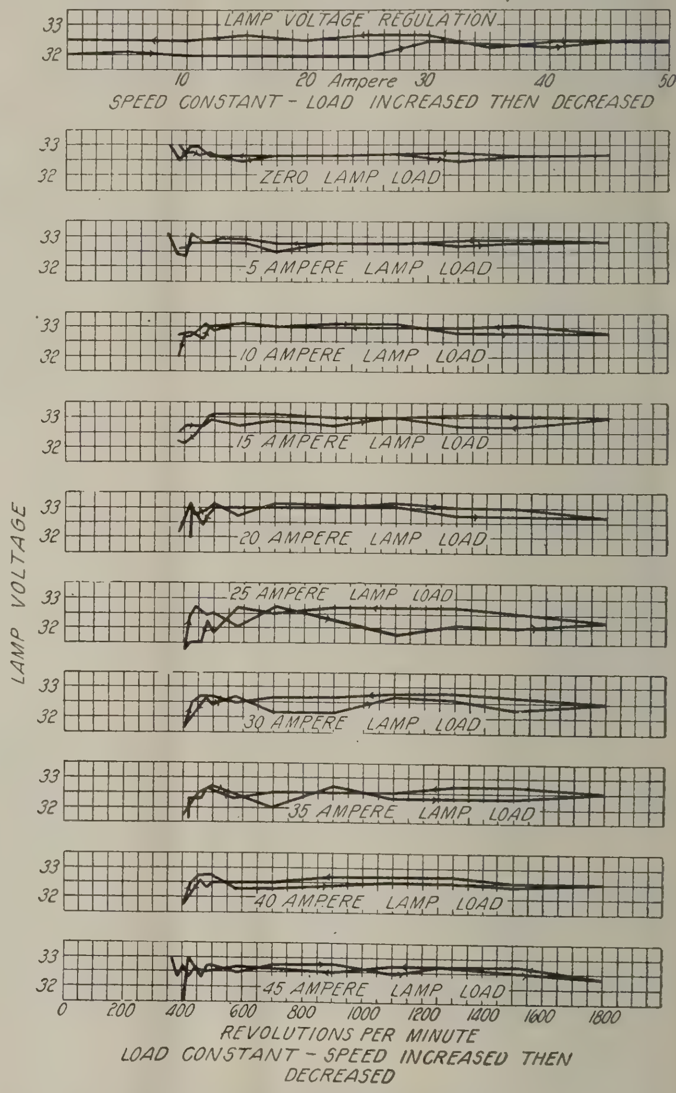


Fig. 15—Curves Showing the Regulation Obtained From Properly Adjusted Lamp Voltage Regulators

Generator Regulator and Lamp Voltage Regulator

While the fundamental idea on which axle generator regulation is based is practically the same for all generators, except those of the controlled speed type, the manner in which the idea is actually worked out is so varied that your committee is unable to word a specification which will cover all the methods employed. The results that are to be attained by means of the type of regulation that may be employed can, however, be defined.

In like manner the means employed to obtain lamp voltage regulation are also too varied to permit covering this item in a specification. The voltage limits within which a properly designed lamp voltage regulator should work can, however, be stated. Curves showing the regulation obtained from regulators properly adjusted are shown on Fig. 15.

Main Generator Fuse Clips

It is desirable that the various pieces of apparatus that are mounted upon the generator regulator and lamp regulator panels may be removed and reapplied without it being necessary to remove the panel from its support. The contacts of the generator main fuse in the armature circuit now shown in Fig. 19, Page 166, Vol. 9, 1916, are one of the parts that it is necessary to renew. To comply with the above recommendation, your committee submits the drawing shown in Fig. 16. This drawing shows a main fuse contact on which the clips can be removed without disturbing the panel.

Regulator Adjustments for Different Types of Battery

In former years the lead-acid-lead battery was used exclusively in car lighting service, but of late the nickel-alkali-iron battery is also used. The charging characteristics of the two types of battery are radically different and it appears advisable that the generator regulator be so constructed that they may readily be adjusted to suit either type of battery.

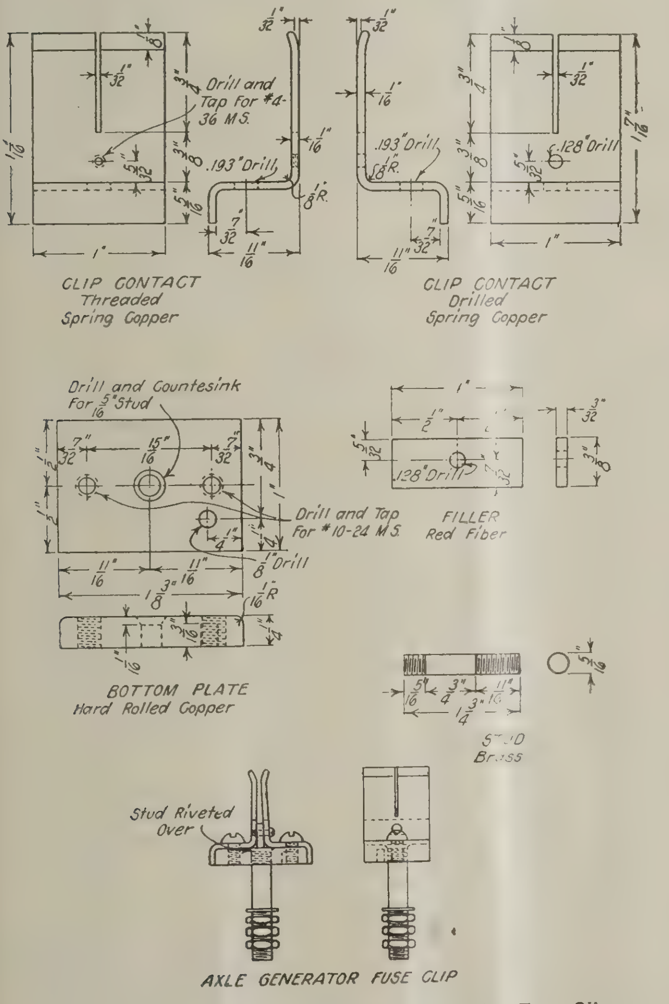


Fig 16—Construction Details of Axle Generator Fuse Clip

Your committee in its 1919 report recommended that the net ampere capacity of an axle generator be based upon a maximum observable rise in temperature of 70 degrees C. and 110 degrees C., instead of the corresponding figures of the American Institute of Electrical Engineers of 65 degrees C. and 105 degrees C. respectively. This was done under a misapprehension of the true meaning of the A. I. E. E. figures and because a comparison of similar tests run on the road and the bench indicated that on the road the generator would operate at a temperature several degrees lower than on the bench. On looking into the matter further, your committee feels that the criticism is well founded. The A. I. E. E. standardization rules specify that the rating of motors and generators shall be based upon a maximum observable rise in temperature of 65 degrees C. and a maximum observable temperature of 105 degrees C. when class "A" insulation is used, the rating taking no account of the conditions of service.

The A. I. E. E., however, recognizes, especially in the case of railway motors, which in their service conditions are more nearly comparable to an axle generator than any other class of motor, that there is a difference between the temperature at which a machine is rated and the temperature at which it may be allowed to operate.

Therefore, your committee has, in submitting these specifications, used the standard temperature values of the A. I. E. E., but would call attention to the fact that under similar conditions of test an axle generator will operate several degrees cooler on the road than on the bench.

Having discussed the various features that must be considered, your committee herewith presents the following specifications for axle generators:

Specification for Axle Generators

1. **General.**—(a) This specification is intended to cover axle generator equipment for the A. B. and C. Railroad, delivery to be made f. o. b. manufacturers' works.

(b) Submission of bid will be understood to imply that the manufacturer fully understands and accepts the requirements imposed by and will furnish apparatus which will comply with this specification.

(c) These axle generators are intended for service on cars having a total load, lamps, fans, etc., of......amperes at 32 volts. Each car will be equipped with......cells of battery of...... ampere hours capacity.

Note—The railroad company shall specify whether the lead-acid-lead or nickel-alkali-iron battery will be used.

(a) The generator shall carry full load at.......miles per hour. (For recommended values of minimum full load speeds, see below.)

Class of service	Approximate maximum load demand	Ampere hour capacity of battery Min.	Max.	Ampere capacity of generator	Minimum full load speed M. P. H.
Official, sleeping, parlor, mail and dining cars having heavy lighting loads, or severe operating conditions..	50	350	600	100	26
Mail, dining cars, etc., where the lighting loads are not so heavy or the operating conditions so severe......	35	300	350	75	26
Coaches, passenger-baggage cars, baggage cars under average operating conditions.	25	200	300	50	21
Same cars as next above operating in slow speed branch line or local service.......	25	150	225	50	16

(e) The material and workmanship shall be the best of their respective kinds.

(f) The accredited representative of the A. B. and C. Railroad shall be the sole judge, on all questions that are not capable of measurement and record, as to whether or not the apparatus complies with the specification.

(g) The apparatus to be furnished shall consist of:
Axle Generator,
Axle Generator Pulley,
Generator Leads,
Generator Lead Terminal Block (to be mounted on car body),
Generator Suspension,
Generator Regulator (with corner brackets),
Lamp Voltage Regulator (with corner brackets),
Axle Pulley,
Axle Pulley Bushing,
Belt and Fasteners,
Lamp Circuit Distributing Panel.

Note.—Any item not desired shall be crossed out.

2. **Axle Generator.**—(a) The axle generator suspension lugs shall be of such design and cross section as to eliminate, as far as possible, liability to blow holes, bubbles or other manufacturing defects which may tend to weaken the ma-

terial in the lug or section of frame adjacent to the lug. The holes in the lug shall not be cored. The design and location of the lug shall be approved by the railroad company. Where there is movement of suspension links or pins in the lugs, the hole in the lugs shall be suitably bushed, the bushing being placed in the lug in such manner that it cannot be lost or move relative to the lug.

(b) The generator frame, pole pieces and end housings shall be machined so that all are in accurate alignment and interchangeable from one generator to another of the same make, size and type.

(c) The end housings shall be machined for the ball bearings with allowance for fit as given below:

HOUSING FITS

Bearing No.	Outside diameter, in. Nominal	Outside diameter, in. Maximum	Outside diameter, in. Minimum	Allowance, in. Maximum	Allowance, in. Minimum
304	2.0473	2.0473	2.0465	+.0026	+.0008
307	3.1496	3.1496	3.1488	+.0026	+.0008
308	3,5433	3.5433	3.5425	+.0026	+.0008
312	5.1181	5.1181	5.1173	+.0030	+.0012
407	3.9370	3.9370	3.9362	+.0030	+.0012
409	4.7244	4.7244	4.7236	+.0033	+.0015
412	5.9055	5.9055	5.9043	+.0037	+.0015

Above allowances are based on a total tolerance of 0.0010 in. for housing bore.

(d) The armature shaft shall be annealed carbon steel having characteristics equal to or better than the following:

Carbon	0.38 to 0.52 per cent.
Manganese	0.40 to 0.75 per cent.
Phosphorus (not more than)	0.05 per cent.
Sulphur (not more than)	0.05 per cent.
Tensile strength, lbs. per sq. in. (not less than)	80,000
Yield Point, lbs. per sq. in. (not less than)	0.5 tensile strength.
Elongation in 2 in., per cent inverse ratio,	1,800,000 ÷ tensile strength.
Elongation in 2 in. (not less than)	20 per cent.
Reduction in area (not less than)	32 per cent.
Reduction in area, per cent inverse ratio,	2,800,000 ÷ tensile strength.

NOTE.—See specifications of the Railway Master Mechanics' Association for annealed carbon steel, Vol. 1a, 1917-1918, page 254.

(e) The armature shaft at the fits for the inner race of the ball bearings will preferably be ground to the diameter, with allowable tolerances as given below for the size of ball bearing to be used:

SHAFT FITS

Bearing No.	Bore Nominal-	Bore Maximum	Bore Minimum	Pressed fit allowance, in. Maximum	Pressed fit allowance, in. Minimum	Pressed fit allowance, in. Desired	Sliding fit allowance, in. Maximum	Sliding fit allowance, in. Minimum
304	0.7874	0.7876	0.7870	+.0011	+.0001	+.0003	—.0001	—.0011
307	1.3780	1.3782	1.3776	+.0012	+.0002	+.0005	—.0001	—.0011
308	1.5748	1.5750	1.5744	+.0012	+.0002	+.0005	—.0001	—.0011
312	2.3622	2.3624	2.3617	+.0015	+.0004	+.0007	—.0001	—.0012
407	1.3780	1.3782	1.3776	+.0013	+.0003	+.0006	—.0001	—.0011
409	1.7717	1.7719	1.7713	+.0014	+.0004	+.0007	—.0001	—.0011
412	2.3622	2.3624	2.3617	+.0017	+.0006	+.0010	—.0001	—.0012

The foregoing allowances are based on a total tolerance of 0.0004 in. for shaft diameter at fit.

Should the bearing be mounted on the shaft by means of an expansion device instead of a press or sliding fit, this expansion device shall be so constructed as to secure relatively the bearing to the shaft and to lock positively under any and all service conditions.

(f) The armature shaft for all axle generators at the pulley fit shall conform to the dimensions shown in Figs. 1 and 2, Pages 85 and 86, Vol. 10, 1918.

(g) The armature shaft pulley nut shall be of the ......locking nut type. The face of the nut adjacent to the hub of the pulley shall be finished square with the axis of the thread.

(h) The armature, as a whole, shall be designed as a unit to permit the ready renewal of the shaft without disturbing any part of the winding.

(i) The commutator bars shall be hard-drawn, drop forged or cast-swedged copper with solid risers. The insulation between bars shall be high grade mica of such design and quality as will wear at the same rate as the bars. The commutator bars shall be insulated from the shell by built-up forms of high grade mica.

The commutator shall be thoroughly seasoned and securely fastened on the shell.

The armature conductors shall be of copper, insulated, preferably with American Institute of Electrical Engineers Class "B" insulation.

(j) Bearings shall be of the annular ball type and of the size specified as follows:

BODY SUSPENDED.

Width of Belt Required to Transmit Necessary Power.

Truck Suspended		Free Speed. 5 In.		Free Speed. 4 In.		Free Speed. 3 In.		Controlled Speed. 4 In.		Controlled Speed. 3 In.	
Pulley.	Comm.	Pulley.	Comm.	Pulley.	Comm.	Pulley.	Comm.	Pulley.	Comm.	Pulley.	Comm.
412	412	412	*412	409	*409	407	407	312	312	307	307
....	....	....	†409	....	†407	....	....	....	†308	....	†304

*Preferred. †Alternate.

Bearing No.	Inside Diameter Inches. Nom.	Inside Diameter Inches. Max.	Inside Diameter Inches. Min.	Outsider Diameter Inches. Nom.	Outsider Diameter Inches. Max.	Outsider Diameter Inches. Min.	Width Inches. Nom.	Width Inches. Max.	Width Inches. Min.	Eccentricity Tolerance's Inches. Inner.	Eccentricity Tolerance's Inches. Outer.
304	0.7874	0.7876	0.7870	2.0473	2.0473	2.0465	0.5906	0.5906	0.5856	0.0006	0.0012
307	1.3780	1.3782	1.3776	3.1496	3.1496	3.1488	0.8268	0.8268	0.8218	0.0008	0.0012
308	1.5748	1.5750	1.5744	3.5433	3.5433	3.5425	0.9055	0.9055	0.9005	0.0008	0.0012
312	2.3622	2.3624	2.3617	5.1181	5.1181	5.1173	1.2205	1.2205	1.2155	0.0010	0.0016
407	1.3780	1.3782	1.3776	3.9370	3.9370	3.9362	0.9843	0.9843	0.9793	0.0008	0.0012
409	1.7717	1.7719	1.7713	4.7244	4.7244	4.7236	1.1417	1.1417	1.1367	0.0010	0.0016
412	2.3622	2.3624	2.3617	5.9055	5.9055	5.9043	1.3780	1.3780	1.3730	0.0010	0.0016

Bearings shall conform to the following dimensions with the allowance and tolerance as given: (S. A. E. Standard).

(k) One end bearing shall be mounted so that the bearing shall have approximately 0.01 in. play in the longitudinal direction of the shaft. The other end shall be mounted so that it shall have at least 1-16 in. play in the longitudinal direction of the shaft.

(l) The end housing shall have one or more circular U-shaped grooves machined in the bore through which the shaft passes; and felt washers, fitting the shaft snugly, shall be applied to the inner side of the commutator end housing and to both sides of the pulley end housing.

(m) The field coils shall be wound with copper, insulated, preferably with the Class "B" insulation of the American Institute of Electrical Engineers.

The field coils shall be form wound, impregnated with a suitable insulating compound to conform to established practices of electrical manufacturers, or thoroughly saturated by the dipping process with insulating material and then baked. The coils shall be covered with at least two layers of insulating tape laid with a half lap. The ends of each coil shall be marked to indicate the inner and outer ends of the coil. The coil shall be placed over the pole pieces and so held as to prevent positively any relative movement of the coil with respect to the pole piece.

(n) The mechanical clearance in the air gap shall be such that

an oval feeler ½ in. wide and 0.05 *in. thick can be passed at all points between the armature and pole faces.*

(o) The pole changer shall be of such design as to throw completely, from one position to the other, in not more than ten revolutions of the armature shaft.

(p) The armature pulley shall be........in. in diameter in accordance with A. R. E. E. Drawing No........and is intended to be driven by a ......in. ......ply belt from an axle pulley .... ..in. in diameter.

(q) Main generator and field leads shall be not less than 40 in. long and shall consist of No. 4 A. W. G. cable of not less than 61 strands, 4/64 in. wall of 30 per cent Para rubber insulation, or equivalent, covered with two braids.

(r) The generator shall be designed to generate rated voltage (40 volts) at load side of generator regulator and to carry full load.........amperes (net current capacity, that is, total current generated, less all field, control and regulating current used in the generator, generator regulator and lamp voltage regulator), at an armature speed not to exceed................r. p. m.

$$\frac{560}{60} \times \frac{\text{Diam. Axle Pulley x Min. full load speed of car in miles per hour}}{\text{Diam. Armature Pulley}} = \text{r. p. m. of armature shaft.}$$

This value shall be known as the "minimum full load speed" in r. p. m. of the generator. (For recommended values in miles per hour see table in Section 1d.)

(s) The generator, with an armature r. p. m. of not more than 75 per cent of the above speed, shall generate sufficient voltage and current to close the automatic switch at the voltage setting as given for same, this speed being known as the "cutting in speed" in r. p. m.

(t) The generator shall be safe to operate both electrically and mechanically at an armature r. p. m. of

$$\frac{560}{60} \times \frac{36}{33} \times \frac{\text{Diam. Axle Pulley} \times 75 \times \text{Factor of Safety } 1.2}{\text{Diam. Armature Pulley}} = \text{Max. Arm. r. p. m.}$$

This value shall be known as the "maximum speed" in r. p. m. of the generator.

(u) At all speeds from cutting in to maximum speed, and at all loads from zero to full rated net ampere capacity, the generator shall operate without destructive or excessive sparking at the brushes, and the armature and armature pulley shall rotate in good mechanical balance.

(v) The generator shall be capable of delivering rated net amperes within a range of 37 to 48 volts. (This requirement is not intended to conflict with the heat test.)

3. **Suspension.**—(a) The generators shall be .... suspended. (The Railroad Company shall insert "truck" or "body.")

(b) The suspension shall be in accordance with the following drawings of the A. B. and C. Railroad, which are hereby made a part of this specification, or they may be in accordance with the manufacturers' standard if the railroad company so elect. (List drawings or cross out section applying to same.)

4. **Belt Tension Device.**—(a) The belt tension device shall be in accordance with the following drawings of the A. B. and C. Railroad, which are hereby made a part of this specification, or they may be in accordance with the manufacturers' standard if the railroad company so elect. (List drawings or cross out section applying to same.)

5. **Generator Regulator.**—(a) The generator regulator panel shall be composed of a non-conducting, non-combustible material having a horizontal dimension of 16 in. and a thickness of at least ¾ in.

(b) The panel shall have four holes drilled in same for the supporting bolts. These holes shall be 7/16 in. in diameter and located 1 in. from the sides and 1 in. from the ends of the panel, giving a horizontal distance, center to center, of these holes of 14 in. (Should it be desired to use a corner bracket with the panel, same shall have the supporting bolt holes drilled 7/16 in. in diameter and so located that when mounted on the panel the horizontal distance between center of holes is 14 in. For attachment to the panel the corner bracket shall be drilled and tapped for a ⅜-in. bolt having 16 threads per in.)

(c) The terminals on the generator regulator panel shall be arranged so that, in a horizontal direction, the positive is at the right and in a vertical direction the positive is at the top.

(d) Each terminal shall be stamped for identification and polarity.

(e) There shall be included with the generator regulator panel, wire terminals for attachment of the wires to the panel terminals; these wire terminals being stamped to correspond to the panel terminals to which they are to be connected.

(f) The apparatus will, preferably, be so mounted on the panel that it may be removed and reapplied without it being necessary to remove the panel from its supports.

(g) The connections between the various pieces of apparatus on the panel shall be, so far as is possible, on the back of the panel and preferably soldered after final adjustment has been made.

(h) The panel shall be supported by four ⅜-in. bolts having 16 threads per inch.

(i) Fuses, fuse contacts and fuse terminals shall conform to A. R. E. E. Standard practice.

(j) The generator regulator automatic switch shall be set to close at any and all operating temperatures at not more than 34 volts, this voltage being attained by the generator at not more than 75 per cent of minimum full load speed.

(k) The automatic switch must open and close without chattering, pumping, sticking or excessive arcing.

(l) The generator regulating apparatus and battery protective devices shall be of such design as to perform satisfactorily all the following functions:

1. Close the main circuit of the generator, by means of an automatic switch, in order to permit current to flow from the generator to the battery and lamps whenever the generator develops proper voltage.
2. Open the main circuit of the generator, by means of an automatic switch, in order to prevent the discharge of the battery through the generator when the r. p. m. of the armature has decreased to a point where its voltage is less than the battery voltage.
3. Automatically prevent the overloading of the generator.
4. Automatically control the rate of charge of the battery.
5. Automatically prevent overcharging the battery either in amperes or ampere hours.
6. In case of open battery circuit the generator shall be able to carry the lamp load and the generator *regulator shall automatically prevent the rise in voltage upon the system exceeding* 120 *per cent of the rated generator voltage.*
7. Means will preferably be provided whereby the adjustment of the regulator can readily be changed from the voltage and current suitable for a lead-acid-lead battery to the voltage and current suitable for a nickel-alkali-iron battery of the same ampere hour capacity, the voltage being capable of being varied independently in the latter case from 1.72 to 1.8 to 1.88 per cell to take care of temperature conditions.
8. For any given condition of battery with any variations of speed at and above 150 per cent of minimum full load speed the regulator shall maintain regulation within 5 per cent, plus or minus, of the value for which the regulator is set for operation. This value to apply equally whether the type of regulation is potential, current, watts or any combination of same.
9. When submitting proposition, the axle generator manufacturers shall describe in detail the type of control of generator output and battery charging that they propose to furnish, submitting such curves as are necessary to afford a complete explanation.

Note—Railroads may substitute for section 5-l detailed specifications covering such type or types of regulation that they desire to consider, provided that the limits are not greater than those given in this specification.

6. **Lamp Regulator.**—(a) The lamp regulator panel shall be composed of a non-conducting, non-combustible material having a horizontal over all dimension of 16 in. and a thickness of at least ¾ in.

(b) This panel shall have four holes drilled in same for the supporting bolts. These holes shall be 7-16 in. in diameter and located 1 in. from the sides and 1 in. from the ends, giving a horizontal distance, center to center of these holes, of 14 in. (Should it be desired to use corner brackets with the panels, same shall conform to the requirements as given under "Generator Regulator.")

(c) The terminals on the panels shall be so arranged that, in a horizontal direction, the positive is at the right, and in a vertical direction the positive at the top.

(d) Each terminal shall be stamped for identification and polarity.

(e) There shall be included with the lamp regulator panel, wire terminals for attachment of the wires to the panel terminals, these wire terminals being stamped to correspond to the panel terminals to which they are to be connected.

(f) All apparatus will preferably be so mounted on the panel that it may be removed and reapplied without it being necessary to remove the panel from its supports.

(g) The connections between the various pieces of apparatus on the panel shall be, so far as is possible, on the back of the panel and, preferably, soldered after final adjustment has been made.

(h) The panel shall be supported by four ⅜-in. bolts having 16 threads per inch.

(i) The lamp regulator shall be so designed that with the complete equipment operating in the normal manner, on bench test or in service, it will maintain the voltage across the lamp mains on the load side of the regulator under the conditions of test as specified below, within the following limits:

1. With the battery discharging and with the battery voltage 31 volts or less, the drop in voltage across the lamp regulator resistance will not exceed one volt per 25 amperes flowing.
2. With armature r. p. m. increasing at an approximately uniform rate from minimum full load speed to maximum speed in not more than five minutes and again decreasing to its original value, the voltage shall be maintained at......volts, plus or minus one volt at any current value not exceeding....amperes.

Note—The railroad company shall fill in the blank spaces. The recommended value for the amperes is 125 per cent of the connected load.

3. With the armature r. p. m. held constant at any given speed between the limits of minimum full load speed and maximum speed, and with the current instantaneously varied by 5 ampere steps, both increasing and decreasing, the voltage shall be maintained at....volts plus or minus one volt.
4. Conditions 2 and 3 shall be complied with under any condition of charge of battery.

Note—Insert value at which it is desired voltage shall be maintained.

7. **Net Ampere Capacity.**—(a) The generator shall have a net ampere capacity of ....amperes. (Net ampere capacity equals total current generated less all current used by fields, control, generator regulator and lamp regulator. For recommended values see Section 1-d.)

8. **Heat Test.**—(a) Connect the generator, generator regulator and lamp regulator (if used) in the normal manner, using rheostat or lamp bank in the battery and lamp circuits.

(b) Remove hand hole covers and operate generator continuously for five hours at the armature r. p. m. corresponding to minimum full load speed with the generator delivering continuously ....net amperes at 40 volts.

(c) Under the above conditions, and with temperatures measured by the thermometer method, no part shall at any time attain a temperature higher than the values given below:

	Insulation A. I. E. E. classification			
	Class "A"		Class "B"	
Part of apparatus	Maximum observable temperature degrees C	Maximum observable rise in temperature degrees C	Maximum observable temperature degrees C	Maximum observable rise in temperature degrees C
Any part of generator regulator, except resistance units, carbon piles, commutator, brushes, brush rigging and bare copper solenoids	105	65	125	85
Commutator, brushes, brush rigging and bare copper solenoids	125	85	125	85

(d) Bearings.—Maximum observable temperature 65 degrees C.

(e) The net ampere capacity shall be determined by the maximum net amperes that can be generated without the above temperatures being exceeded.

9. **Insulation Test.**—(a) Immediately after the heat test all parts of the equipment shall withstand, without breakdown, an alternating potential of 1,000 volts, applied between conductors and ground, for a period of one minute, all metallic parts except conductors being grounded.

10. **Badge Plate.**—(a) Each generator shall have attached to it a badge plate on which the following information shall be shown:

1. Manufacturer's name.
2. Manufacturer's type and serial number.
3. Nominal voltage.
4. Rating in amperes.
5. Minimum full load speed in r. p. m.
6. Pulley ratio.

Note—The railroad company shall specify whether these blanks are to be filled in with the actual pulley diameters, which it is intended to use or with the pulley ratio, the diameter of the armature pulley being taken as one.

11. **Rejection.**—The A. B. & C. Railroad reserves the right to reject:

(a) Any equipment, or part thereof, that fails to comply with the requirements of the specification when inspected at time of delivery.

(b) Any equipment, or part thereof, that is defective in any way (material, workmanship or details of design) which might reasonably have been overlooked when approving the plans.

(c) Any equipment, or part thereof, that is responsible for an excessive number of failures in service, or that is found to be defective in material or workmanship within one year of date of delivery.

12. **Patents.**—(a) The manufacturer shall insure the A. B. & C. Railroad against any and every loss arising from claim that the apparatus, as furnished, infringes patents not owned or controlled by the manufacturer and shall furnish the A. B. & C. Railroad, when requested, a satisfactory bond to cover such contingency.

13. **Guarantee.**—(a) The manufacturer shall correct, without charge to the A. B. & C. Railroad, any defect due to design, material or workmanship which develops within one year from date of delivery of the equipment.

14. **Data.**—(a) Dimension drawings in as full detail as may be necessary to afford thorough understanding of the equipment offered shall be submitted to and approved by the A. B. & C. Railroad before manufacture is begun.

15. **Shipment.**—(a) No equipment shall be shipped until same has been accepted by the A. B. & C. Railroad or inspection waived and shipment authorized.

Note.—The railroad company when requesting bids shall fill in all blanks indicated, thus..........

Increased Clearances in Battery Boxes

Your committee was instructed to look into the subject of providing increased vertical clearance in battery boxes for the purpose of facilitating inspection and flushing of batteries without necessity for partially withdrawing the batteries. In addition there is a tendency in the improvement in the design of lead storage batteries to increase their height, particularly for the larger capacities, to provide greater sediment and acid space. The present minimum inside height of battery boxes as recommended by the association is 21-½ in., while the overall height of standard designs of train lighting batteries varies from 18-⅞ in. to about 19-¼ in. There have been brought out lead batteries of improved construction having an overall height of 21-¼ in. and to top of cover 19-¼ in.

To obtain information as to the desirability of recommending an increase in the minimum height of battery boxes a questionnaire was sent out. Eight railroads replied, five recommending a clearance between the cover of the battery and top of the box of from 4 to 7-¼ in., the majority being approximately 6 in. Three railroads recommended a minimum inside height of battery box of from 23 to 23-½ in. Your committee would recommend as representing good practice that for future battery box construction a minimum inside height of 23 in. be provided.

With respect to this report, your committee recommends the adoption of the axle generator specification with the changes that were accepted at the June convention and with the understanding that with its adoption it will automatically supersede recommendations in previous reports that conflict with this specification.

Report of Committee on Illumination

Lamp Manufacturers Put New Schedule Into Effect As Result of Committee's June Progress Report

Committee

L. S. Billau (chairman), assistant electrical engineer, Baltimore & Ohio.

A. E. Voight, car lighting engineer, Atchison, Topeka & Santa Fe.

J. L. Minick, assistant engineer, Pennsylvania System.

A. H. Gerald, engineer, assistant to chief electrician, Pullman Company.

YOUR committee submits the following report:

(1) **Changes in Method of Rating Train Lighting Lamps.**—The change in rating of train lighting lamps from the constant lumen to constant wattage basis as presented in the progress report at the June meeting and adopted by the association was submitted to the lamp manufacturers, who have put the following schedule for train lighting lamps into effect:

Lamps for Train Lighting Service

LAMPS FOR TRAIN LIGHTING SERVICE

Watts	Bulb	Lumens	Lumens per watt
	Standard Schedule 30-34 volts Mazda B Lamp		
Straight side bulb			
10	S-17	94	9.4
15	S-17	144	9.6
25	S-17	244	9.76
50	S-19	506	10.1
Round bulb			
10	G-18½	87	8.7
15	G-18½	137	9.14
25	G-18½	231	9.24
50	G-30	515	10.3
	Mazda C Lamp		
50	PS-20	739	14.78
75	PS-22	1,210	16.12
	Intermediate Schedule 30-34 volts Mazda B Lamp		
20	S-17	195	9.75
20	G-18½	185	9.25
	60-65 volts		
Straight side bulb			
15	S-17	137	9.14
25	S-17	239	9.57
50	S-19	506	10.1
Round bulb			
15	G-18½	131	8.74
25	G-18½	221	8.85
50	G-30	515	10.3
	Mazda C Lamp 30-34 volts		
100	PS-25	1,676	16.76
	60-65 volts		
75	PS-22	993	13.23
100	PS-25	1,461	14.61

Due to the decreasing demand for lamps in the 60 to 65 volt range these lamps will be listed in the intermediate schedule only.

(2) **Changes in Rating of Locomotive Cab Lamps.**—The 15 watt S-17 bulb locomotive cab lamp will be manufactured in the future as a 33-volt lamp only instead of a 34-volt lamp and will have a distinguishing label placed upon it, marked: "Locomotive cab lighting."

(3) **Baggage Car and Coach Illumination Tests.**—Your committee arranged to have conducted some tests in coach and baggage car illumination with a view to obtaining data showing results to be secured with the 50-watt PS-20 bulb Mazda C train lighting lamp as compared with the 50-watt Mazda B lamp that has heretofore been the general standard for train lighting purposes:

a. **Coach Illumination Tests.**—Tests were conducted on a standard 70-ft. day coach equipped with 10 center deck lighting units located on two seat spacing. The location of the test stations, compiling of data, etc., followed the same procedure as used in the day coach lighting tests conducted by the A. R. E. E. at Cleveland in 1913, except that lumen values for the lamps now in effect are used instead of the 400 lumen value as used for the 50-watt Mazda B lamp in those tests. For purpose of ready comparison the results obtained with prismatic velvet finish reflector with the 50-watt Mazda B lamp as obtained in test 8, page 23 of the day coach test, but corrected to the value of 506 lumens per lamp, are shown in the following:

Kind of reflector:	Velvet finish prismatic glass				Medium density opal	
Type of reflector:	Holophane 18,226VF				Sudan 18,678	
Lamp:	50 Watt S-19 Mazda B		50 Watt PS-20 Mazda C		50 Watt PS-20 Mazda C	
Lamp position for reflector	⅜ in.		1⅛ in.		1⅛ in.	
Lumens per lamp.......	506		740		740	
Illumination plane.....	45 deg.	Hor.	45 deg.	Hor.	45 deg.	Hor.
Illumination in foot candles						
Window seats	1.90		3.06		3.90	
Aisle seats	2.45		4.40		5.54	
Average seats	2.18	2.91	3.73	5.95	4.72	5.86
Aisle only		4.16		7.86		7.80
Average car		3.15		6.34		6.25
Per cent total light delivered on horizontal plane		35.3		44.0		43.2

b. **Bagage Car Illumination Tests.**—Tests were conducted in a standard 70-ft. baggage car equipped with eight center deck lighting units on approximately 8 ft. 9 in. spacing, the units being mounted as closely to the ceiling as possible:

Kind of reflector:	10 in. cast iron shallow dome		12 in. shallow dome porcelain enameled steel				12 in. RLM porcelain enameled steel	
Lamp:	50 Watt S-19 Mazda B		50 Watt PS-20 Mazda C		50 Watt S-19 Mazda B		50 Watt PS-20 Mazda C	
Lamp position in reflector reflector					⅝ in.		0 in.	
Lumens per lamp.	506		740		506		740	
Illumination plane horizontal—above floor....	33 in.	46 in.	33 in.	46 in.	33 in.	46 in.	33 in.	46 in.
Illumination in foot candles								
Center of car—average		3.4		5.1		3.5		5.3
18 in. from wall—average		2.3		3.3		2.4		4.2
Car—average...	2.3	2.7	3.3	3.9	2.3	2.8	4.0	4.6
Per cent total light delivered on 46-in. horizontal plane.		42		41.5		43.5		49
Illumination on vertical plane 18 inches from wall.								
Location of station:	a	b	a	b	a	b	a	b
Height above floor--								
33-in...........	.08	.06	1.6	1.1	1.1	.03(?)	1.7	1.5
46-in...........	1.5	1.0	2.3	1.5	1.6	1.2	2.8	2.0
72-in...........	3.4	1.4	6.2	2.7	4.8	2.3	8.0	2.9

a—Station located 18 in. from wall directly opposite lighting unit near center of car.

b—Station located 18 in. from wall half way between two lighting units near center of car.

It will be noted that by substituting the 50-watt Mazda C train lighting lamp for the 50-watt Mazda B lamp it will result in a very large increase in illumination and at the same time this lamp can be obtained at a lower first cost than the round bulb 50-watt G-30 Mazda B lamp. Your committee therefore recommends the general use of the 50-watt PS-20 Mazda C. lamp in place of the 50-watt Mazda B lamp for train lighting purposes. It should be realized, however, that on account of the high intrinsic brilliancy of the Mazda C lamp it should only be used with deep bowl or other type of reflector or enclosing glassware that will very largely cut off the direct rays of light from line of vision of the passengers.

(4) **Standard Lamp Positions.**—Your committee has found that practically no standards exist with respect to the position of lamp bulb and reflector. As a consequence, in changing from one type of reflector to another or in changing the type of lamp bulb it is frequently necessary to change this lamp position in order to obtain the correct distribution of light. With many types of fixtures in use this is impossible or at least can be done only at considerable expense. Your committee, therefore, has made a study of the subject with

a view to recommending certain positions to be adopted as standard, and that as far as practicable lighting fixtures for train lighting purposes should be so designed that these positions can be readily changed. For center deck type of fixture this can be accomplished by mounting the socket on a stem independently of the shell of the fixture which carries the reflector and providing means so that the socket position can be raised or lowered as necessary. For other designs of fixture suitable pieces to serve as spacers to be placed between the socket and fixture support can be used. The fixture, however, must be so designed that the socket can be mounted so as to obtain the highest lamp position. After considerable study of the subject the following lamp positions are recommended as standard for steam railroad train lighting purposes, these positions representing the distance from the top edge of the reflector to the end contact of base of lamp:

1½ in., 1 in., ½ in., 0 in.

For convenience in designating these positions it is recommended they be expressed with numerals corresponding to the position in fourths of an inch, i. e., the designation for the above positions will be known as Nos. 6, 4, 2 and 0.

In studying this subject your committee has conferred with the reflector manufacturers and others who have tentatively approved these positions and if adopted by the association will be guided by them in designing reflectors in the future.

With reference to lamp positions now in general use these compare very closely with those types of reflectors where accurate lamp position is necessary to obtain the proper distribution of light with the exception of the 1⅛ in. position which is the standard for 50-watt G-30 bulb lamp with Holophane prismatic reflector. With the availability of the 50-Watt Mazda C lamp it is felt that the use of the 50-Watt Mazda B lamp will gradually be discontinued. As it would be undesirable to change the lamp position in making this change in lamps unless absolutely necessary to do so, the light distribution obtained with the 50-watt PS-20 Mazda C lamp in the 1⅛ in. position was looked into and found to be satisfactory with the velvet finish reflector although the 1 in. position, which will be the future standard, gives a slightly better distribution. This makes it entirely feasible to use the 50-watt Mazda C lamp with the deep bowl reflector in fixtures having the 1⅛ in. position and in the future adopting the 1 in. position without necessity for changing the design of the reflector or without obtaining unsatisfactory light distribution.

Your committee recommends that the association take definite action with reference to these lamp positions at this meeting in order that the matter may be formally referred to the manufacturers at as early date as possible.

Report of Committee on Electric Welding

Emphasis Laid on the Requisites for Successful Welding. Many Valuable Test Data Being Compiled

Committee

E. Wanamaker, (chairman), electrical engineer, Chicago, Rock Island & Pacific.

H. C. Meloy, supervisor electrical equipment, New York Central.

H. R. Pennington, supervisor of welding and electrical equipment, Chicago, Rock Island & Pacific.

G. T. Goddard, general electrical foreman, Illinois Central.

YOUR committee has made a careful review of the report presented by your welding committee at the annual convention in October, 1918. That report, in fact, so far as this committee is able to ascertain, was the most complete electric welding report that has ever been prepared, and it was ably supplemented by the report of your committee in 1919. During the year 1920 there has been no marked extension or change in practice such as would justify detailed description in this report, with the possible exception of the bringing out of an automatic electrode feeding device by the General Electric Company, which is still under process of development and commercial completion.

The users of the electric arc welding process have just begun to evince a great and proper interest in the use of improved welding electrode materials, method of testing welds, proper application of design, etc. The American Welding Society is just now preparing a new system of organization, so that, with its various sections or chapters, it will be able to advantageously supply a long-felt need of the users of all forms of autogenous welding. This society is preparing to work very closely with the welding committee of Section III—Mechanical—of the American Railroad Association, and in view of the probable amalgamation of the Association of Railway Electrical Engineers with Section III—Mechanical—A. R. A., it seems highly important that this electric welding committee be continued, in order that it may supply a great deal of the detail as to welding equipments, materials, method of design application, testing, etc., to the welding committee of Section III.

Your committee feels that it is entirely proper and apropos to say once more that the autogenous welding industry, including electric arc welding, is still in its infancy. It is known that there are complications entering into all calculations tending toward the reduction of cost of maintenance and operation. This requires a large broadening in the range, abilities, and scope of the electrical engineers, if they are to contribute as they should to the continued investigation and research which no doubt will be a necessarily continuous process for some years to come.

As it is demonstrated satisfactorily that by certain methods various jobs can be safely and economically welded, the lines of limitation should be carried further afield. At present excellent equipment is available for all forms of autogenous welding, but again your committee deems it expedient to call your attention to the three prime requisites that must be completely and thoroughly met if the application of this process is to be a success. These requisites are:

(1) Proper material for making the weld; (2) rules and methods for properly using these materials; and (3) intelligent application of the process to the various mechanical devices or articles that are to be welded.

It should be realized by all that in any autogenous weld the best that can be done is to obtain good cast iron, cast steel or alloy steel in the weld, the casting in this case being the added metal in the weld, or, in other words, the weld itself. No effort should be spared to secure the proper materials for welding. If high grade materials are to be joined, whether the joint be in truck frames or boiler steel, the proper materials for constituting the weld should first be secured.

No expense or pains should be spared in an unswerving endeavor to thoroughly train mechanics until they are capable of making first-class welds with a high average of efficiency and factor of safety.

To secure success (or, perhaps better still, lasting success) in electric arc welding, the co-operation of all concerned is an absolute necessity, including the mechanical engineer, the engineer of tests, or metallurgist, the superintendents of motive power and rolling stock, the master mechanic, the foreman, and the operators themselves. Fully 90 per cent. of all welds that have failed in service have been due to the use of the wrong welding material or unfamiliar or unintelligent application in the design, or inexpert execution of the weld.

It was the hope of your committee that it would be able this year to place before you a vast quantity of test results that have been secured during the past three years, but in view of the fact that months are required to complete these tests, and for the metallurgist at the laboratory to prepare the micro-photographs for reproduction, it has been found necessary to postpone the furnishing or publishing of all these data until next year. However, your committee is able to state that tests completed up to date indicate that welding performed with the electric arc is just as essentially a heat proposition as a weld performed or executed in any other manner. It is felt by the committee that when this association is able to publish these data and information it will prove of much help and a great safeguard in extensively extending the application of the electric welding art. For instance, the building up of cross head fits on carbon steel piston rods for locomotives is one example of what can be done. After 18 months of test and research it has been developed, beyond a doubt, that this job can be economically and safely performed, provided the part is carefully annealed after the weld is completed.

It may be stated that the requirements necessary for securing good welds vary broadly—first by group and then by detail member or class. Group arrangement is as follows: Plate material, shapes, forgings, cast iron, cast steel and malleable iron; and yet another (and one which is just now coming to be a very important one), viz., track steel.

The plate group may be subdivided into two classes, first—where free or loose plate material is welded, and, second—when welded in structural or vessel form, which may in turn be again sub-divided into non-pressure, low-pressure and high-pressure vessels. All non-ferrous metals are classed together in a second general classification.

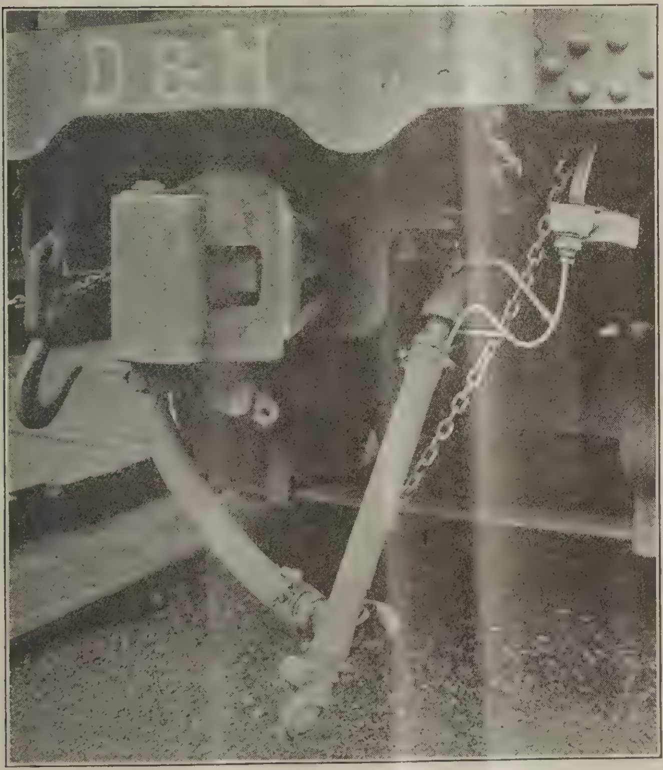
In conclusion, it may be well to say that your committee feels that it would not be advantageous to submit a report at this time, other than the progress report which has just been outlined, because the present developments are in the evolutionary stage and the test data and research matter gathered during the past three years are not in shape to present at this time.

For the benefit of those who receive these committee reports prior to October 12, especially those who are vitally interested (and all should be) it might be interesting to know that on October 12 T. D. Sedwick, engineer of tests, Chicago, Rock Island & Pacific, will present a paper on the testing of welds and establishment of proper methods of procedure, etc., at a meeting of the American Welding Society, Chicago section, in the rooms of the Western Society of Engineers, Monadnock building, Chicago. It was impossible to present these data in this report, as they was not completed in time. Those who are interested, but unable to attend the meeting of American Welding Society, may be able to secure a copy of the paper from the society.

The committee recommends that the report be received and the committee continued.

United States Electric Train Signal

The Delaware & Hudson Company has in use on a local passenger train an electric signal, taking the place of the usual air signal, and it has been tested for over a year. It is giving satisfactory service. The train circuit is normally closed, so that any failure of battery or wires would be at once revealed. The electric apparatus, an electro-magnetic valve, sounds a whistle. There is a whistle, with a miniature semaphore, not only on the engine but also one in each car of the train, and all signals are audible and visible throughout the train. The whistle on the locomotive is loud enough to be heard readily above any conflicting noise. With this arrangement each signal given to the engine is repeated in each car, and it is possible with a suitable code for the engineman to signal to the conductor at any time. Signals are, of course, communicated instantaneously. The train circuit is energized by gravity batteries—4-volt—one in each car.


Electrical Connections for Trains. Signals Are Made Through Hose and Coupling

The train is made up of a locomotive and four cars and runs between Troy, N. Y., and Rutland, Vt., 86 miles, six round trips a week. The circuit controller in each car is actuated by the usual cord extending the length of the car. Air is taken from the brake system train line.

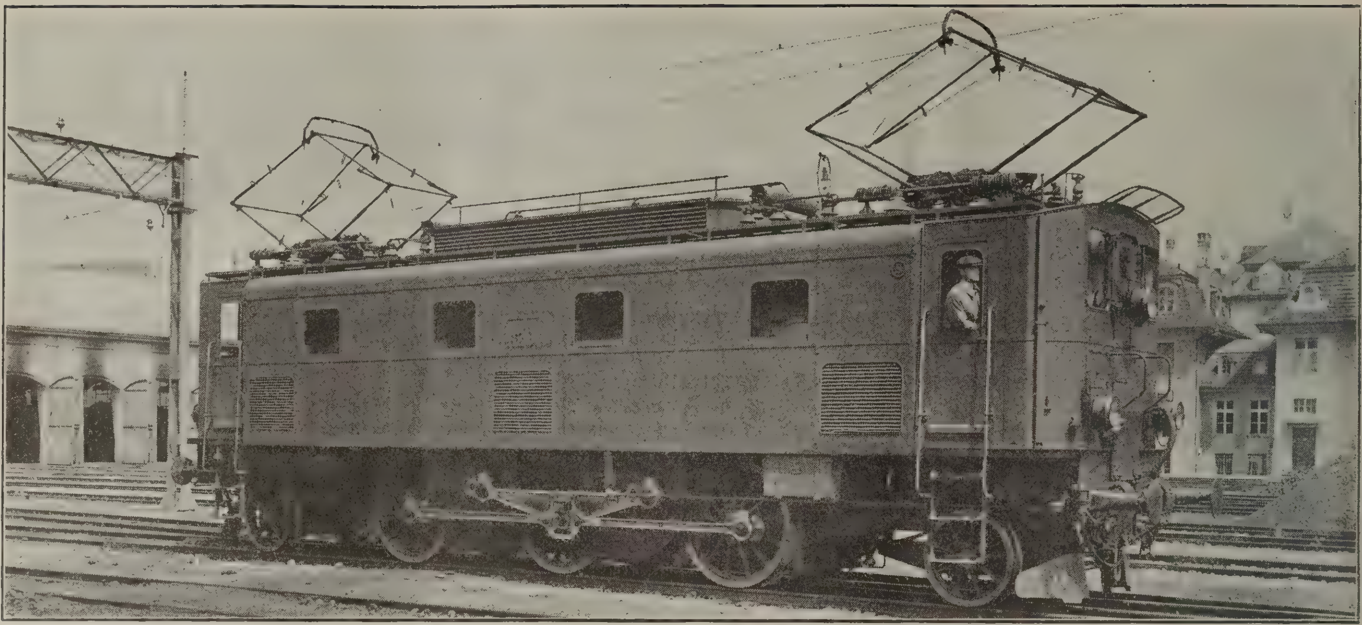
The connection between the cars is by means of insulated wire in the brake hose coupling, and the man who couples the air hose by the same operation completes the electrical connection. The couplings are insulated.

The electrical connection through the hose is said to be as effective as a separate connection could be, and its cost is less. This installation was in use throughout last winter and there was no trouble from ice or snow.

The experiment on this short train has illustrated the advantage and practicability of such a signal on freight trains, and except for the difficulty incident to using foreign cars, the system could be adapted to the longest train. It would be available also for telephone communication between the locomotive and the caboose. Extensive experiments, continuing through the winter, were made also, two or three years ago, on the Canadian Pacific and the Canadian National.

The proprietor of this system is the United States Train Signal Company, 97 Exchange Street, Portland, Me., and it is patented by William E. Benn and George E. Davies.

The apparatus on the Delaware & Hudson train was inspected and tested last June by the Bureau of Safety of the Interstate Commerce Commission. W. P. Borland, chief of the bureau, reporting on this test, says that "the device is designed upon sound principles, and if properly installed and maintained it is capable of producing reliable train signal indications."



Express Locomotive Type 1-C-1

Electric Locomotives for Swiss Federal Lines

Interesting Points in the New Equipment Recently Received for Operation on the St. Gothard Line

THE $25,000,000 loan recently floated in the United States by the Swiss Federal Railways, has been the means of drawing sonsiderable attention to the activities that are going on in connection with the electrification of the Swiss Federal Lines. It is understood that whatever portion of the $25,000,000 loan will be spent in this country will be used in the purchase of such material as steel tubing, copper, insulators and possibly rails rather than for completely finished machinery. Indications are that not much of the total amount will be used for copper, as the Swiss government has been able, since the signing of the armistice, to purchase enough copper in Europe to supply their needs until 1922. The main factor in the case which makes the electrification of this road so urgent is the great difficulty of obtaining coal and its high cost. This condition is the one which is chiefly responsible for the important movement to develop and utilize as rapidly as possible the water power resources of the country which are still untouched.

Several of the latest types of electric locomotives for operation on the St. Gothard section of the system have recently been delivered by the Oerlikon Company. Inasmuch as the three locomotives are similar in general design the essential details have been here given concerning the smaller express locomotive and the details and features of the other two only where they differ from the first. In many cases, such as in the current collectors, the designs are identical.

Express Locomotives—Type 1-C-1—Mechanical Parts

Type of wheel-base 2-6-2.—In this type of locomotive Bissel trucks are used at each end, the axles having side-play of 2x3.14 in., the trucks being kept central by two plate-springs each, bearing direct over the axles and pivoted. The central (coupled) axles are allowed side-play of 2x1 in. for easy running over curves.

Motors.—The motors are high-speed, placed centrally in the locomotive. Spur-wheel gears on each side with a gear ratio of 1:2.84 bearing on to the first motion-shafts, which are connected by a triangle-frame, from which the driving wheels are connected up by a direct connecting-rod. The middle bearing of the triangle-frame is made to slide, to allow of play for the separately sprung central axle. To absorb shock, the motor-axle is built with sprung spur-wheel pinions, and the plate-lengths of the frame (cut solid and 1 in. thick) are sprung longitudinally and transversely so as to unite the truck and driving axles.

Locomotive body.—The locomotive includes two completely separated drivers' cabs, two transforming and oil-distributing cells each, and the motor-space between. The walls of the body are removable. Movable ladders lead to the roof, and on placing these ladders in position the overhead wires are brought into contact with an airpipe, which sounds a warning signal if the collector is not lowered and at the same time lowers it.

Brake-Blocks.—There are 12 brake-blocks on the coupled wheels, with a total pressure of about 80 per cent of the adhesive weight. Each brake-axle has double fittings and a brake-cylinder as well as a spindle-brake. Half of these blocks can be worked by hand.

The chief dimensions of Type 1-C-1 and 1-B+B-1, both of which are express locomotives, are given in the table on the opposite page.

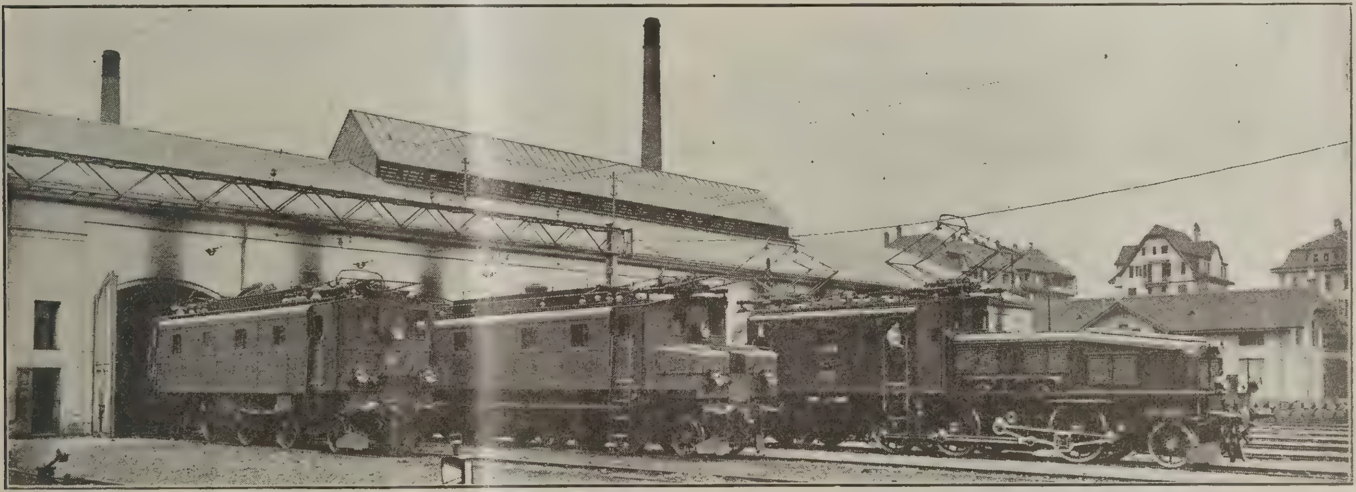
Electrical Parts of Type 1-C-1

There are two compensating 12-pole series motors with phase-shifting auxiliary field. They are reversed by reversing the current in the exciting-coil by means of direct electro-pneumatically guided current-changing cylinders. By the use of two motors economy of parts is effected, as well as the use of current-changing by a "cascade" regulating switch, by which better graduations of speed are obtained, as many as 23 grades being obtainable, either electro-pneumatically or by hand.

Chief Dimensions—Types 1-C-1 and 1-B + B-1

	1-C-1	1-B + B-1
System of current	Single-Phase Current	Alternating Current
Tension	15,000 to	7,500 volts
No. of periods per second	16⅔	16⅔
Maximum tractive power	29,800 lb.	39,700 lb.
Normal speed	31 miles per hour	31 miles per hour
Maximum speed	46.5 miles per hour	46.5 miles per hour
Gauge	4 ft. 8½ in.	4 ft. 8½ in.
Diameter of driving wheels	4 ft. 5¼ in.	4 ft. 5¼ in.
Diameter of truck wheels	3 ft. ¾ in.	3 ft. ¾ in.
Length over buffers	44 ft. 4 in.	53 ft.
Total wheel base	32 ft. 9 in.	43 ft. 4 in.
Fixed wheel base	15 ft. 5 in.	9 ft. 6 in.
Minimum curve radius on open track	590 ft.	590 ft.
Minimum curve radius through points	374 ft.	374 ft.
Weight of mechanical portion with fittings	46.5 tons	58.5 tons
Weight of electrical portion with fittings	44.5 tons	54.5 tons with regeneration
Total weight of locomotive	91 tons	113 tons
Axle pressures	16.25+3x19.5+16.25	16.5+4x20+16.5 tons
Friction weight	58.5 tons	80 tons
Frictional coefficient for conveying	1:43	1:44
Weight per running foot	2.06	2.14 tons per foot

Transformers.—Two graded transformers, dry and artificially ventilated, feed the two motors from each switch with choking-coils and over a disengaging current-reverser. If necessary one switch can drive both motors. The high-tension circuit contains two "shears" collectors, two separating-knives to separate the collectors, two choking-coils as lightning-conductors, two more separating-knives to cut off the high-tension side, two high-tension entrance wires, two high-tension oil-distributors, two primary coils of the transformers, two disengaging current-reversers, a measuring current-reverser and two earth-contact rings.



All Three Types of Locomotives. From Left to Right—Express Type I-C-I, Express Type I-B+B-I, and Freight Type I-C+C-I

The "Shears" collectors.—The shears collectors allow a variation in height of the transmission wire of 15 ft. 9 in. to 23 ft., so that the pressure of the contact-bow remains constant. The up-and-down movement of the collector is regulated by counter-springs and air-pressure and guided pneumatically.

The separating-knives.—These are isolated and are used to cut off defective collectors and the high-tension circuit. They can be worked only when the collectors are lowered, by a key which also opens the high-tension chambers; the latter, on being opened, automatically connects up the high-tension current with the earth, as a measure of safety.

The High-Tension oil-distributors.—These can be worked from both cabs, either electro-pneumatically or electro-magnetically, or if necessary by hand with a rod and key.

Auxiliary machinery.—Two groups of compressed-air pumps, three groups of ventilators and one of transformers are used in connection with a battery. The groups of compressors which produce the air-pressure for the brakes provide 42.3 cu. ft. of air per minute at from 5 to 7 atmospheres of pressure. Air is supplied to the motor-chamber by a ventilator, at the rate of about 21,200 cu. ft. per minute for a 15 mm. column of water. Both transformers can be cooled by air-blast, at the rate of 2,650 cu. ft. of air for a 70 mm. column of water.

A group of transformers carrying the current for the starting-gear and for lighting, consists of a single-phase induction motor and a continuous current shunt-dynamo, which works parallel with two normal illumination batteries placed in series.

There is also apparatus for electric heating. Besides the driving motors and auxiliaries, an additional current of 400 amperes at 1,000 volts being led from the transformers for this purpose.

The locomotive can be used for multiple operation. In this case one man in the first locomotive can control the motors of both.

Express Locomotive Type 1-B+B-1—Mechanical Parts

Type 2-4-4-2.—A "bridge" is constructed over the wheel-base, and the body of the locomotive is screwed down to this. The weight of the body is carried on sprung pivots and bearings in front and at one side of the motors. As these pivots are necessarily placed at a distance from the centre of the body, roller bearings distribute the weight of the motors. In contrast to the 1-C-1 locomotive the Bissel ponies are fitted with wedge-back guides. Each bogie has between the driving axles two driving motors, placed low, working direct and with centrifugal ventilators for artificially cooling the motors. By means of toothed wheels (gearing ratio 1:3.47) placed on both sides and joined by a motion-shaft, the driving motors work on to their respective driving-wheels through two slotted coupling-rods placed at right-angles. Air to cool the motors is drawn in through the ventilators by pneumatically-guided shutters or flaps placed at the sides of the locomotive body. Cut-off valves between the bogies and the locomotive body prevent the absoption of four air through the ventilators. There is also a screw-ventilator in the roof, working air into the transformer-shaft. In other respects this locomotive is similar to 1-C-1.

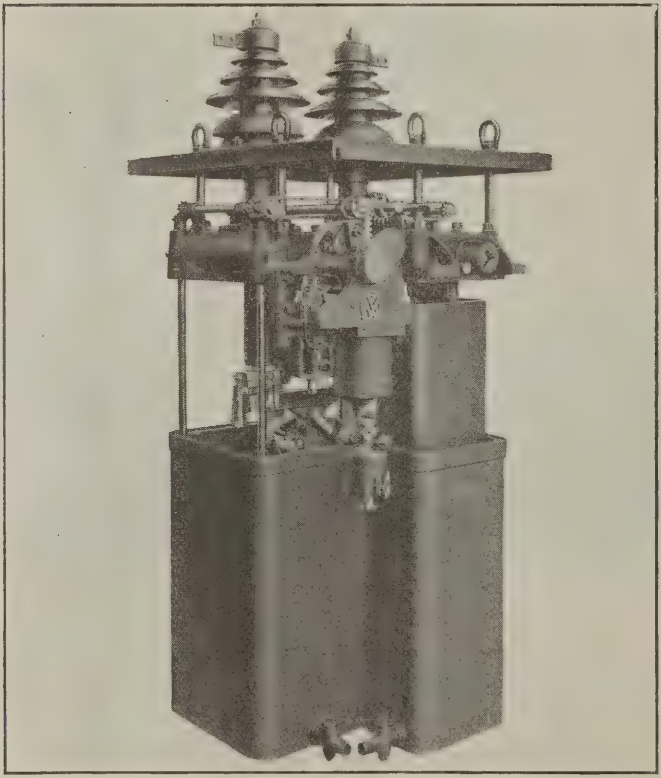
Electrical Parts of Type 1-B+B-1

The line-tension of 15,000-7,500 volts is transformed to the tension of the motor by one graded and oil-cooled transformer. The two low-tension windings arranged in series have 23 grades, as in the 1-C-1.

An innovation on this locomotive is the installation of electric braking by regeneration. In other respects it is similar to 1-C-1.

Freight Locomotives Type 1-C+C-1—Mechanical Parts

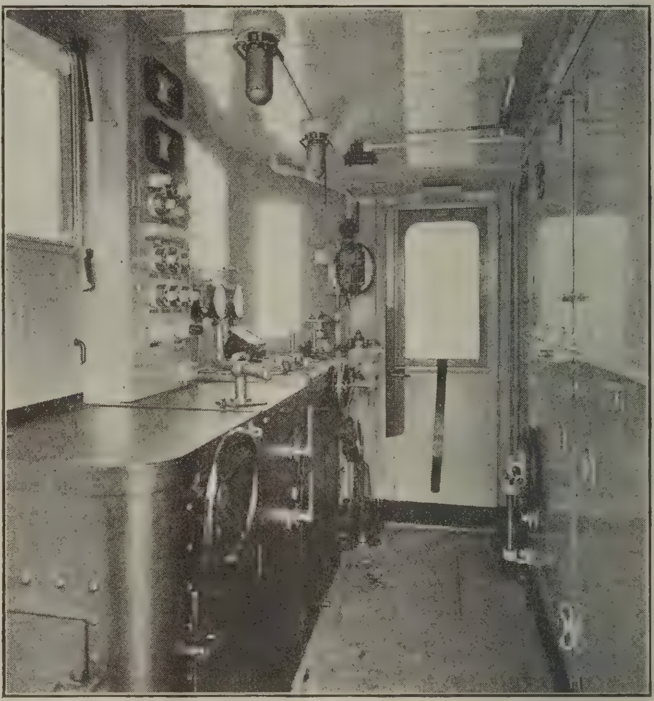
Type of wheel-base 2-6-6-2.—For For running on curves the central driving-axles have 1 in. side-play while the axles of the Bissel trucks have side-play of 3.27 in. each. To distribute axle-pressure the bearing-springs of the first driving-axle are connected by compensating-levers with the truck-axle on one side, and the second driving-axle with the third on the other. The two driving-trucks are exactly alike and interchangeable. They are joined by a short-coupling, in which a plate-spring is fixed. Pull and thrust movements are thus communicated direct from one truck to the other.



The Top of the Oil Switch Forms a Part of the Roof of the Cab

The four driving-motors are fixed in the driving-truck frames, and are placed in pairs. They are geared to the motion-shafts by toothed wheels on both sides, gearing ratio 4.03:1.

All the driving-axles are fitted with two brake-blocks, worked either by hand with crank and spindle or by Westinghouse double-brakes. Each truck has a 15 in. brake-cylinder, and with the Westinghouse a maximum of 80 per cent of the total adhesion-weight can be attained; with the hand-brakes, a maximum of 90 per cent of the adhesion-weight of one truck only. There are four sand-boxes, two before and two behind the driving-axles.



View Looking Across Cab Interior Towards Engineman's Position

The locomotive body is divided into three parts, of which the outer two are each fixed to one truck, while the centre is supported by both trucks. The outer parts are covered with sheet-metal.

In each cab is a manometer for the air-pressure apparatus and tachometer (Hasler System).

In other respects this locomotive is similar to the express locomotives already described.

CHIEF DIMENSIONS—TYPES 1-C+C-1

Maximum Speed	40.4 miles per hour.
Length over Buffers	63 ft. 7 in.
Total Wheel-Base	54 ft.
Bogie Wheel-Base	22 ft.
Fixed Wheel-Base	15 ft. 5 in.
Diameter of Driving-Wheels	4 ft. 5¼ in.
Diameter of Truck-Wheels	3 ft. ¾ in.
Diameter of Crank	1 ft. 11½ in.
Gearing Ratio of Toothed Wheels	1:4 .03
Height of Locomotive Body	12 ft. 4 in.
Width of Locomotive Body	9 ft. 8 in.
Weight of Mechanical Part (including Westinghouse brake)	70.6 ton
Weight of Electrical Part (including installation for regeneration)	56.4 ton
Weight of personnel fittings, driving-gear, etc	1 ton
Weights of Locomotive in working order	128 ton
Axle Pressures	12.0+18.2+4×16.9+18.2+12.0 ton
Frictional Weight	104 ton
Weight per meter total length of locomotive	2 ton per foot

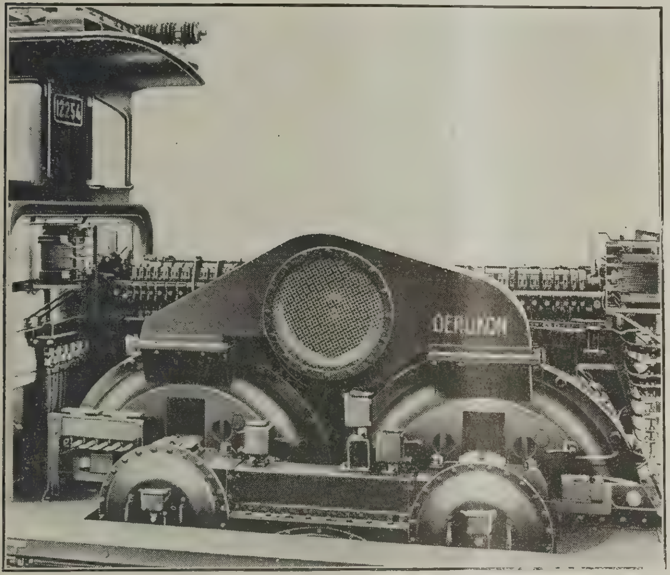
Maximum Ascent 26 per cent gage, curve-radius, etc., same as express locomotives.
Tension, 15,000-7,500 volts + 5 per cent = 15 per cent.
No. of periods 16⅔ per second.

Electrical Parts of Type 1-C+C-1

For the most part the electrical features are similar to those of express locomotive, type 1-B+B-1. The graded transformer (oil-cooled) is intended for erection in the open, and stands in a shaft open to the air at top and bottom; the cover forms part of the locomotive roof. In this way the air inside the locomotive does not become heated and the transformer can easily be removed for repairs, when the collector is at its full height.

An oil-transformer keeps dust arising from the brakes and moisture from penetrating into the machinery.

Owing to the weathering of the overhead wires through smoke, soot, etc., the middle traveling-wire tension is only half the normal tension, *i.e.*, 7,500 volts, and in accordance with the connection of the driving-motors the primary coil is divided into 4 groups, two each being connected in parallel. Apart from the transformer the change of tension can be effected by exchanging the connections (by means of four isolators) with the groups of coils.



Gears and Pinions of Motors are Enclosed. Control Switches are Shown in the Background

There are 2 independent secondary installations, to feed the motors and heat the train.

The heating apparatus has a maximum tension of 1,180 volts, with gradations of 1,000 and 800, regulated by a permutator, which is connected to a measuring and disengaging current-changer by a single-pole oil-heating switch. The permutator can only be adjusted when the oil-switch is without current. From the switch the heat-current is carried to the train through heat-couplings, two of which are fixed on each beam of the locomotive. The return-current is carried through the wheels and metals to the earth contact-rings of the locomotive. The oil-switch also has part of the roof to form its cover, and as a safety earth-current switch is placed round it, there are no danger-points within the locomotive from which accidents could happen.

An induction-coil is placed on the roof of the transformer to prevent over-tension.

The motors are compensating series motors with phase-shifting fields (Wendefelder), of half-closed shape. Between the collector and the armature-coils there are no resistance-connections. On the collector are 12 sets of brushes with 5 carbons each, 1.57 in. wide and .035 in. thick.

Electric braking is installed, with recovery of expended energy. A brake choking-coil is fitted, and also a small choking coil, which is connected in parallel to the auxiliary pole coils of the motors so as to increase the commutation of the motors on applying the brakes. The brake is regulated by the controlling-apparatus which is also used for the motors, and the same switch is used to change the tension.

In other respects this locomotive is similar to the express types.

Testing High Tension Insulators

At the convention of the National Electric Light Association, which was held in Pasadena, Cal., the report of the Overhead System Committee described a number of methods practiced by different companies for the testing of high tension insulators. The testing of insulators is divided into two divisions, namely, tests made before the insulators are put into service, and tests made after they have been installed.

In testing insulators before they have been put into service two general methods are used, one, a high frequency test, and the other, a normal frequency test. In making the test by the former method the insulators are tested with high frequency, the potentials being as a rule just below the flash-over value. When the normal frequency test method is applied the insulators are tested under high potentials, and at normal operating frequency, the voltage being raised to the flash-over value, although some companies prefer to keep the potentials just below the flash-over point.

There is a wide difference of opinion regarding the relative merits of these methods of tests. Some of the advantages and disadvantages claimed are as follows:

There is no more likelihood of damaging a good insulator with the high frequency test because of the steeper wave-front and the greater dielectric loss.

The high frequency test set is more portable than the low frequency test set.

The high frequency test gives more even distribution of corona, and for that reason picks out any faults more readily than the low frequency test.

The low frequency test is the one commonly used by manufacturers.

In addition to the foregoing tests made before installation quite a number of companies periodically test insulators in service. The methods used by these companies are as follows:

Megger Method.—The resistance of the insulators is measured with a megger, which is applicable to either pin type or suspension type insulators. It is necessary to take the line out of service in performing this test. The instruments employed vary in capacity up to 5000 megohms-1000 volts. Two men are needed to make this test, one stationed on the pole or tower holding the leads on the insulator, and the other operating the instrument. Insulators are considered defective if the resistance is less than a pre-determined figure, which is not the same for the various companies, each one having its own standard. These values vary from 500 to 5000 megohms. The results secured seem to be generally satisfactory, although there are certain types of defects in insulators which this test will not reveal.

"Buzz Stick" Method.—A few companies use the

"buzz stick" method of testing insulators. This test has been developed for both pin type and suspension type insulators and is made with the lines alive. It is more especially adapted for tests on the latter type, and the description given applies to suspension insulators.

This method depends upon the electrical capacity of the insulator unit. The only tool used in testing is the "buzz stick." This is a long handled tool with a two pronged metallic fork on the end, with which the insulator units may be short-circuited. The test in general consists of two steps: the first is to indicate whether there is a sufficient number of good insulators in the string to make it safe to apply the second step, which involves short-circuiting each individual unit. The first test consists of touching one tine of the fork to the cap of each insulator, beginning with the one supporting the conductor. As contact is made, a small spark is produced which represents the charge taken by the prongs of the testing stick to bring them to the potential of the cap. Since the cap potential decreases as the test progresses from the conductor to the point of support, the spark produced diminishes. If an insulator is defective, its cap will have the same potential as the cap of the one preceding it, and the spark will be the same. The tester judges by the noise made by the spark whether there are any defective insulators in the string.

If this test indicates that there are enough good units in the string to permit the short-circuiting test to be applied, each unit is then short-circuited, beginning with the one supporting the conductor. In this test, the spark produced is caused by discharging the insulator which is, of course, acting as a condenser. Each succeeding insulator is charged to the voltage of the cap of the preceding insulator, and since the capacity of an insulator would be decreased if it were defective, a bad insulator is indicated by the absence of a spark when short-circuited, or by an abnormally small spark. This test is much more sensitive than the first test, as it enables the tester to judge much more accurately whether an insulator is defective.

Since this method depends upon the electrostatic capacity of the insulator for its operation, it will naturally indicate only the faults existing in the porcelain between the cap and pin, and will not indicate faults in the disc which would lower the flash-over voltage. Furthermore, before this test will indicate defective porcelain between the cap and pin, the defect must have decreased the electrostatic capacity of the insulator.

The companies using this test state that it gives very satisfactory results, the lines being kept remarkably free from insulator failures.

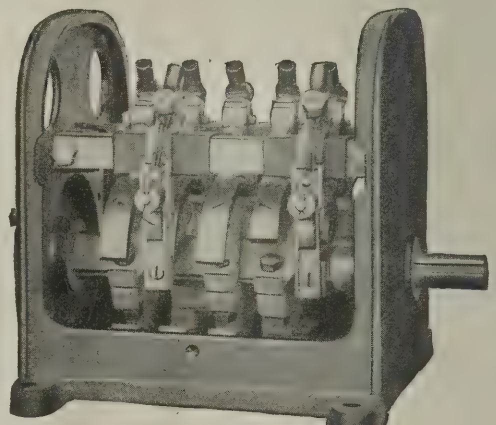
Telephone Receiver Method.—Five companies report the use of telephone receivers with exploring rods for testing insulators. The tester uses a high resistance telephone receiver, one terminal of which is mounted on the end of an exploring rod and the other terminal grounded. The person testing walks along the line holding the ungrounded terminal of the receiver high in the air, and bringing it close to each pole. A defective insulator is indicated by a distinctive grating sound in the receiver, which is easily distinguished from the hum caused by the small leakage current flowing over the surface of the insulators. This kind of test is not so well adapted for suspension insulators, as it does not readily indicate defective units in the string. Similarly, on multipart pin insulators it does not give an indication when only one part is defective. It is, of course, necessary for the line to be alive to employ this test.

"Keokuk" Method.—One company reports the use of the "Keokuk" method of testing insulators. The apparatus used is a self-contained testing fork, the tines of which are connected across the high tension winding of an automobile induction coil mounted on the handle. The low tension winding of the induction coil is energized from three dry cells carried in a container at the end of the fork handle, a snap switch being provided in the battery leads. In series with one of the high tension leads, connected to the tines of the testing fork, is an ordinary spark plug which forms an air gap. The tester places the fork across the insulator to be tested, and if the insulator is defective, sparking occurs across the spark plug. In making this test it is necessary to take the line out of service.

Elevator Controllers

The entire line of d. c. and a. c. elevator controllers manufactured by The Cutler-Hammer Mfg. Co., of Milwaukee, has been replaced by a new line of controllers of fewer types and simpler construction for intermittent elevator service. Although the new controllers retain the general design of the previous ones, they have in addition the following main features: standardized carbon-to-copper power contacts, which are non-freezing and quiet in operation, and time limit acceleration by a simple dashpot relay, which is accurate in operation and provides smooth acceleration under all loads.

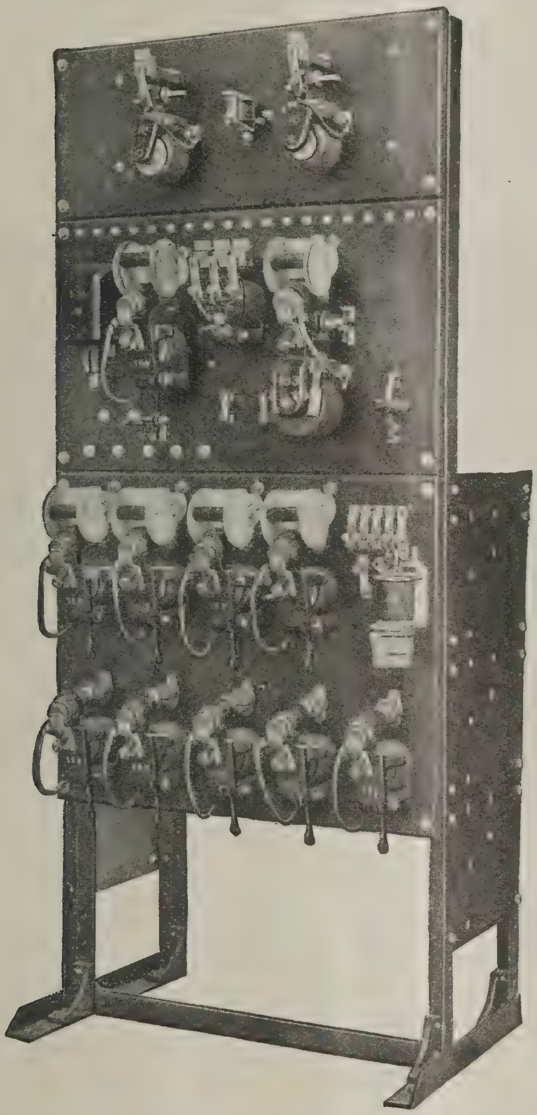
With d. c. equipments, acceleration is effected by cutting resistance out of the armature circuit. The time interval allowed the motor to come up to speed is determined by the setting of a dashpot relay which is externally adjustable for time values, and when once set will always cut the resistance out of circuit in the same length of time. The relay consists of a magnetic solenoid which actuates a plunger moving in an oil dashpot. As the plunger moves upward, upon closing the pilot circuit, it rotates a rocker arm carrying a series of fingers, which cut out the resistance step by step in the controller and causes the accelerating magnet switches to close one by one.



Reversing Switch With Cover Removed Showing Construction and Arrangement of Segments and Fingers

The resistor, which was automatically inserted in the solenoid circuit in the former controllers, has been omitted, as the coil is of sufficient size to prevent overheating on intermittent duty, without having to reduce the current when the plunger reaches the end of its stroke.

The dashpot is totally enclosed, preventing oil leakage or splashing, and has an exterior adjusting screw for time regulation. A special dashpot oil is provided, with a viscosity which varies only slightly over wide ranges in temperature. A test was conducted with this relay from 30 degrees to 90 degrees F., without changing the dashpot adjustment, showing variation in time of less than 10 per cent.



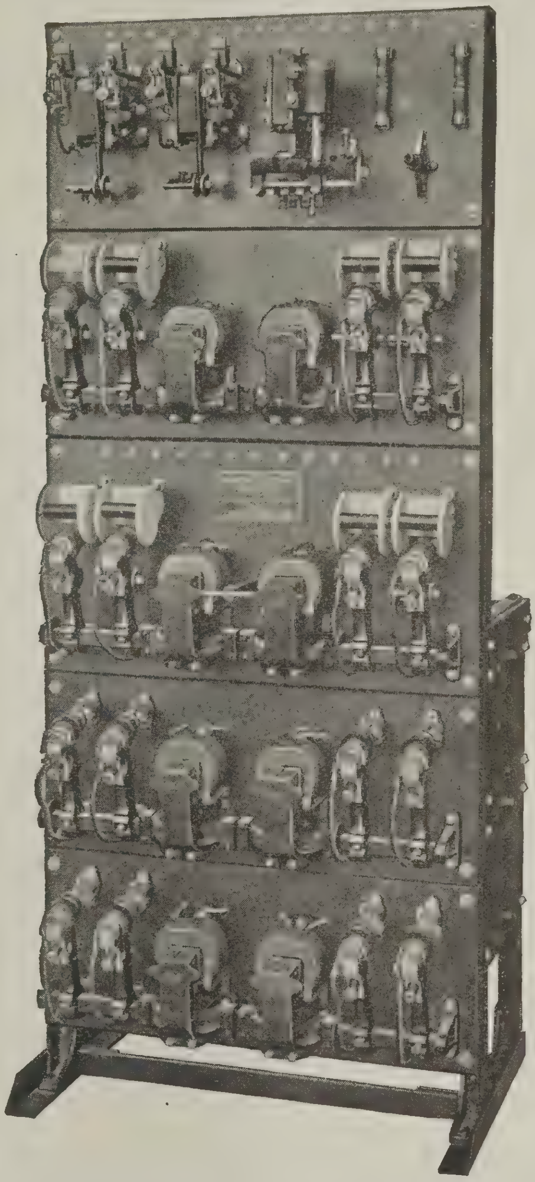
Direct Current Full Magnetic Elevator Controller With Two Speed, Slow Down and Dynamic Brake

The elevator controller consists of a main line contactor and timing relay, mounted on a slate panel and carried on a wall type frame, and is controlled by the reversing switch, which is operated from the cage by wheel, lever or rope. The magnetic main contactor on the control panel has carbon-to-copper contacts and a strong magnetic blowout. It makes and breaks the main line circuit, thus relieving the reversing switch of that duty. The series field of the motor is cut out in one step after starting and the design is such that the motor can be reversed only when all the starting resistor is in circuit.

The reversing switch has the fingers inverted with reference to the former design. This makes the terminals readily accessible when the cover of the switch is removed, and the copper dust from the contacts falls to the bottom of the switch without danger of causing a short-circuit between poles.

A controller of the same type designed for heavier duty has magnetic accelerating switches in the motor circuit, and the dashpot mechanism is used as a pilot relay.

The d. c. full-magnetic controllers for operation by car switch or push buttons are of the same general design as those previously described, but have magnetic reversing switches on the control panel, and are built for one or two speed service. Five and six steps of acceleration are provided on single speed, and eight steps on two speed. A two speed controller may be supplied up to 400 feet per minute. Dynamic braking and overload protection are furnished as standard equipment on all two



Alternating Current Full Magnetic Elevator Controller for Slip Ring Induction Motors on Two Speed Elevators speed equipments, and single speed equipments rated over 25 hp., and are furnished on other controllers when desired.

The controller for car switch or push button operation consists of a double-pole primary contactor, two double-pole reversing contactors, and three and four double-pole accelerating contactors, controlled by a timing relay. This controller may be used with elevators hgving any number of landings.

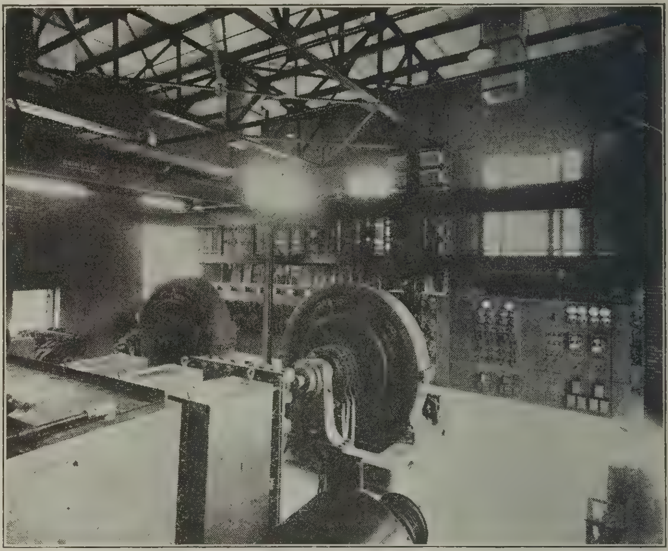
Both a. c. and d. c. equipments are arranged so they may be used with electric brakes. Standardized carbon-to-copper contacts are employed on all controllers, and these contacts are interchangeable on a. c. or d. c. equipments of like capacity. Only two sets of power contacts, nominally rated at 100 and 200 ampere capacity, are used. Larger equipment is furnished on special order. When so ordered, these equipments are supplied with overload relays, non-interference relays, limit switches, and other protective devices.

Rotary Converters in Automatic Substations

With the advance in the use of full-automatic sub-stations to heavy traffic trolley and multiple-unit interurban service, the use of this equipment for electrified steam lines will in all probability become a reality in the near future. The two 1500 kw. rotary-converters just installed in the new Heights Substation of the Cleveland Railway Company are about the size which would be necessary to furnish direct-current energy for electric locomotives and multiple unit motor-cars on steam lines. This installation is interesting, for when automatic substations were first installed several years ago to take care of small loads, little thought was then given that "laborless" equipment could be used where larger units were installed and heavy service was to be taken care of.

The Heights Substation Showing Arrangement of Outgoing Feeders

The two 1500 kw. Westinghouse rotary-converters in this station are each equipped with the circuit-breaker, transformer and automatic control equipment. Although the station does not carry a load continuously at least one of the units will be operated from about 4 A. M. until midnight. This machine will be placed on the line automatically when the cars in its district start running and the trolley voltage drops below normal. After this happens it will take the unit about 40 seconds to get started and convert energy for the transportation system. It will continue to take care of the load until the time arrives when it will carry full load for about 15 minutes. At this time, the second machine will be started automatically to take its share of the load. This will carry the load through the morning peak, the second machine continuing to operate until it carries only 50 per cent of normal load. Fifteen minutes after this point is reached, the second machine will shut down leaving the first machine to supply the energy for the day load. Then, when the evening load comes on and goes off the second machine will be started and stopped to meet the conditions. At midnight when the cars stop running the first machine will shut down automatically. Besides being designed to take care of varying conditions as described, precautions have been taken to meet all difficulties that can be foreseen. For this purpose there are eighteen protective relays, each one functioning as conditions for its use arise.


There are Two 1500 Kw. Rotary Converters in the Substation Together With Switching, Transforming and Automatic Control Equipment

The new substation is taking care of city load which is outside of the two mile limit of the Cedar substation and the load of the new Cleveland Interurban Railway Company line which is being operated by the Cleveland Railway Company. The interurban line extends about two miles beyond the Heights substation so that its load can be easily taken care of. In addition the station will relieve greatly the load on the Cedar substation which is in the most intensely populated residential section of the city.

The difficulty of obtaining proper maintenance men sometimes encountered in the installation of automatic substation equipment was obviated by the Cleveland Railway Company in a manner that has proved successful. When the stations were first contemplated it was seen that several high-class men were desirable who would be well informed as to the lay-out of the station in order to find trouble and properly maintain the equipment. For this reason L. D. Bale, engineer of substations, who has spent the past year and a half in the study of automatic operation, picked three likely men and initiated a school wherein he and the men studied intensively, the complete working diagrams and schematic diagrams of the station. Questions were raised as to what would happen if a relay failed to operate or if certain conditions were present and the answers were obtained by actually working through the circuits. In addition, a separate wiring diagram was made for each piece of apparatus so that in case of trouble the exact cause could be located with the least difficulty and in the quickest possible manner.

The equipment for the four automatic substations was designed by the engineers of the Westinghouse Electric & Manufacturing Company, working in close conjunction with the engineers of the Cleveland Railway Company. In this connection it is to be observed that the practical experience of the operating company proved to be of no little value to the designing engineers. In numerous instances the engineers of the operating company were able to point out the need for protective devices and relays to provide for various operating contingencies. The manufacturer then designed and constructed the apparatus with which to meet these needs.

Steel Melts From Inside

A Discovery Made by G. P. Blackiston

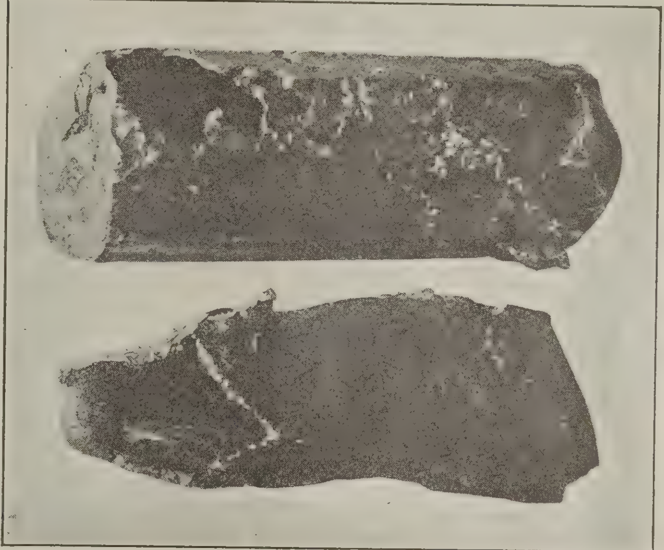
New things continue to happen, new inventions continue to be found, and new discoveries are occasionally made despite the oft heard proverb "There is nothing new under the sun." Perhaps in no field more than in the steel field, have greater, more far-reaching discoveries of scientific value been made in recent years. Only twenty years ago a man, whose name is found to live long in the records of mechanical achievement, made the momentous discovery that steel containing certain alloys possesses an entirely new and distinct property, called red-hardness. It was about this time that F. W. Taylor stumbled, as it were, while engaged in a work of an entirely different nature, upon this remarkable fact, a fact of so much importance that the new steel, which became known as high-speed steel, was the impetus that was responsible for the revolutionizing of the then common manufacturing processes. For this new steel was able to remove metal, when shaped into cutting tools, at so fast a speed and feed and at a depth of cut so great, that truly the world was astonished when its properties were demonstrated.

And now comes G. P. Blackiston, and announces to the world that steel melts from the inside. Like Taylor's, Blackiston's discovery was an accident. We do not know what its value will be to the steel trade but will tell the story as it comes from the lips of Mr. Blackiston himself, whose desire is to give the information freely and let all who may, profit from it.

This new discovery was made by Mr. Blackiston, a practical steel man, while at work in a crucible steel plant. As is well known in the manufacture of crucible steel, the mixture for melting consists of definite and carefully weighed amounts of certain grades of wrought iron, blister bar, alloys and scrap which are packed in pots. These pots when filled and covered, are placed in a furnace which contains a number of holes—six pots, three deep and two abreast, being placed in each hole. The holes are then covered and the pots are subjected to a heat of about 3,000 degrees F., for a period of from two to three hours. After the mixture is melted, the pots are allowed to stand in the furnace until all the gas in solution has boiled out and the molten steel is then ready to be cast.

In the mixture used at the time that the discovery was made, numerous pieces of octagon bar steel such as is used for chisels and rectangular bar steel, such as is used for lathe and planer tools, were found. After the pots had been packed, placed in the furnace, and the melting was well under way, one of the pots broke and was immediately removed from the furnace and set to one side.

Let us examine briefly what was revealed by an investigation into the mass of metal found in this broken crucible, which had been subjected to the high heat of 3,000 degrees F. for a short time. After the pot had cooled, it was observed that chunks of metal were present which seemed to have the original shape they possessed at the time they were inserted in the pot. By tapping them with a hammer, a hollow sound was noticeable and upon further investigation, the pieces were indeed found to be hollow. They were carefully removed and are shown in the photographs. It will be observed that the pieces removed from the pot are two hollow shells that have retained their original contour, except that in the process of melting the molten metal in the inside found a weak spot in the outer shell and passed out through the opening shown.



Two Hollow Steel Shells As Taken From the Crucible

The reasons for this are not so obvious. As is well known, pure iron has a higher melting point than steel and the more carbon there is in the steel, the lower its melting temperature. The outer layer of these bars of tool steel received the heat first, but this heat was, no doubt, immediately transferred to the inner portion, as the heat continued to be added. We do not know where this may lead us. Perhaps the principle may be applied to the manufacture of articles now made in an entirely different manner, in a new and cheaper way.

General News Section

The Arrow Electric Company, Hartford, Conn., manufacturer of switches and other electrical equipment, has awarded contract for construction of an addition to its plant, 33 ft. x 40 ft.

The Westinghouse Electric & Mfg. Co. announces that it has received within the past three months orders from electric power companies for over a half million horsepower of turbine-generators. The same company has awarded contract for the erection of a one-story addition to its plant at Essington, 120 ft. x 200 ft., to be used as a foundry.

According to reports reaching Department of Commerce Japanese railway authorities have decided to substitute electricity for steam on all lines within Empire. Change, which, it is estimated, will cost 200,000,000 yen, is expected to reduce the number of locomotives in service by 40 per cent.

Announced from Honolulu that, according to Tokyo cable to *Nippu Jiji,* a Japanese newspaper there, Japanese Government has decided to open wireless communications between its Funabashi and Iroki stations and Hawaii, California, Oregon, Washington and British Columbia stations for daily press quota of 500 words.

The General Electric Company, Schenectady, N. Y., has filed plans for the construction of a one-story building at its plant at Columbia avenue and Putnam street, Baltimore, Md., recently acquired from the government. The factory will be used for the manufacture of electric switches and other specialties. It also announces that the Fort Wayne Electric Works of the company at Fort Wayne, Ind., has filed plans for the erection of a building there, at Wall street and Broadway, to cost about $325,000.

Chicago Union Station Company.—This company has let a contract to the Underground Construction Company, Chicago, for building the substructure on the south side of the new viaduct at Roosevelt Road, Chicago. The Underground Construction Company has also been awarded a contract for the installation of conduit lines between Harrison and Polk streets with the W. J. Newman Company, Chicago, and will construct the sub-sidewalk to be laid in connection with the widening of Canal street, between Harrison and Van Buren streets.

The Roller-Smith Company, New York, N. Y., announces the appointment of the Mountain States Machinery Company, 1710 Glenarm Street, Denver, Colorado, as its agent in the States of Colorado, Wyoming and New Mexico. The Mountain States Machinery Company (successors to Vaughan Co.) will handle also the products of other concerns such as the Crocker-Wheeler Company, Maloney Electric Company, Cutler-Hammer Manufacturing Company and the Terry Steam Turbine Company.

The Cutler-Hammer Mfg. Co. of Milwaukee and New York have moved its Chicago office from the Peoples Gas building, where they have been located for the past eight years, to the company's own building at 323 Michigan avenue. The change was necessitated an account of the rapidly growing business in the Chicago territory. Considerable extra storage space is also available which will make it possible to carry a larger amount of stock of standard apparatus and parts ready for delivery. **H. L. Dawson** is manager of the Chicago office, which handles the business of nineteen states with sub-offices in Cincinnati and Detroit.

The Western Electric Company, through its board of directors, has promulgated an order extending the vacation privilege to every department. Previously factory workers did not receive the same benefits as the members of the sales, clerical, technical and executive branches and any time off during the summer months was taken at their own expense. When the new system was anounced at the Hawthorne works near Chicago, **J. W. Bancker,** Assistant General Superintendent of the plant, said: "This is believed to be one of the first instances in the history of the Chicago industry where annual vacations with full pay have been extended to factory employees of all classes." The innovation was decided upon to afford some substantial expression of appreciation for faithful service. In extending the vacation privilege the length of service is the basis of eligibility. Employees who have been with the company 10 years are allowed two weeks with pay, while those who have been in its employ five years and less receive one week.

The Traffic Club of New York held its September meeting on Tuesday evening, September 28, in the Hotel Waldorf-Astoria, New York. A. H. Armstrong, of the General Electric Company, spoke on the subject "Steam vs. Electricity," and W. A. Schumacher, of the United Fruit Company, gave a talk describing the banana industry. Mr. Armstrong's talk was illustrated with lantern slides, was general in character and was punctuated with facts which indicated that he is making preparations to meet any counter claims which may be made by the steam locomotive advocates. Mr. Schumacher described the origin and growth of the banana industry and described in detail the manner in which bananas are brought to market, laying particular stress on the need of having ventilated refrigerator cars for shipping them. His address was concluded by a carefully prepared motion picture which followed the development of the banana from the time it was planted until it reached the consumer.

Electrification of the Belgian Railways

The Belgian Minister of Railways has recently made the following statement concerning the proposed Government program of electrifying the Belgian railway system. The first part of the program to be carried out is the electrification of the 44 kilometers of double track between Brussels and Antwerp. The first step to be taken is the electrification of the passenger service only, which will call for the introduction of enough electric engines and cars to insure 38 trains a day in each direction, each with a seating capacity of 500 persons. Before the war the number of trains between Brussels and Antwerp was 34 in each direction daily. The cars are to be of the European metal or semimetallic type. The type of engine adopted as a basis for calculation is equipped with four motors of 275 horsepower. The average speed of electric express trains is to be about 40 miles an hour, and the maximum speed about 54 miles. When the electrification of the passenger service is completed, more electric engines will be introduced and used for drawing freight trains. Steam locomotives not required on the non-electrified lines will continue to be used on the Brussels-Antwerp line until worn out.

After the Brussels-Antwerp track, the Brussels-Luxemburg will be the next to undergo electrification, after which will follow the lines from Brussels to Ostend and Cologne. At an early date electricity will be introduced on the network of freight connections in and around Brussels. The electrification of branch lines serving rural districts will be carried out gradually, and the final elimination of the steam locomotive will be a matter of a good many years.

Steam and Electric Locomotives to be Compared

The relative advantages of modern steam and electric locomotives are to be described in four papers to be presented before a joint meeting of the New York Section of the American Institute of Electrical Engineers, the Metropolitan Section of the American Society of Mechanical Engineers and the Railroad Section of the A. S. M. E., to be held October 22, in the Engineering Societies building, 29 West 39th street, New York. The papers on steam locomotives will be presented by J. R. Muhlfeld, vice-president, Railway and Industrial Engineers, Inc., and W. E. Woodard, vice-president, Lima Locomotive Works. The papers on electric locomotives will be presented by A. H. Armstrong, chairman electrification committee, General Electric Company, and F. H. Shepard, director of heavy traction, Westinghouse Electric and Manufacturing Company. The following men have agreed to take part in the discussion: W. L. Bean, mechanical assistant, New York, New Haven & Hartford; A. W. Gibbs, chief mechanical engineer, Pennsylvania system; F. H. Hardin, chief engineer motive power and rolling stock, New York Central; F. W. Kisel, Jr., mechanical engineer, Pennsylvania system; C. H. Quinn, chief electrical engineer, Norfolk & Western; A. L. Ralston, mechanical superintendent, New York, New Haven & Hartford; and R. Beeuwkes, electrical engineer, Chicago, Milwaukee & St. Paul. The meeting will be conducted by a joint committee of the three society sections, will be opened by Frank J. Sprague, Sprague Safety and Signal Corporation, and George Gibbs, chief engineer electric traction of the Long Island, will close the discussion.

Electrification of Brazilian Railroads

Consul A. T. Haeberle, Rio de Janeiro, in writing to Commerce Reports quotes a report which appeared in the Jornal do Commercio of Rio de Janeiro, on July 14, 1920, to the effect that the Commission of Finance of the Federal Congress of Brazil has signed the proposal of Mr. Sampaio Correa regarding the electrification of some lines of the Estrada Ferro Central do Brazil, a government-owned railroad. The following resolution was unanimously adopted: The executive committee has been authorized to open a credit of about $11,000,000 to cover the cost of changing the railroad system from steam to electricity on the suburban lines from the central station in Rio de Janeiro to the following stations: Deodoro, Barra do Pirahy, Santa Cruz, Paracamby and Maritima. The executive committee is also ordering the plans for the prolongation of some or all lines to the center of the city, if possible to the Praca Mauá, having authorized the opening of the necessary credit, if the project is approved by the prefect of the federal district.

Electrification of Italian Railways

According to an announcement in the Trade and Commerce Weekly Bulletin, a new government decree, substituting the one published last August, unfolds the lines along which the electrification of the Italian railways is to take place. In short, the scheme as now outlined includes the electrifying of 2,750 miles and the laying of 6,070 miles of new rails. The plan calls for (1) the immediate electrifying of 803 miles and the laying of 1,780 miles of rails; (2) the electrifying of 635 miles and the laying of rails over 1,410 miles in the period immediately following the execution of the first group; (3) the electrifying of 1,080 miles and the laying of rails over 2,640 miles by private industry; and (4) the electrifying of 158 miles and the laying of rails over 242 miles, in which group experiments will be made with new methods of electric traction. The government for this work has apportioned about $154,000,000 to be distributed over eight periods, about $11,600,000 to be expended in the current financial year.

PERSONALS

J. A. Cooper, foreman in charge of the electrical work of the Decatur (Ill.) engine terminal of the Wabash Railroad, has been appointed chief electrician of the entire road with headquarters at Decatur, Ill.

George L. Bebout, sub-station operator at pier No. 9, of the Chesapeake & Ohio Railway, with headquarters at Newport News, Va., has been promoted to the position of electrician at Ashland, Ky., succeeding **James F. Briant,** who resigned to enter the automobile supply and service station business.

H. Heider, shop electrician of the Chicago, Rock Island and Pacific at Cedar Rapids, Iowa, has been made terminal electrician at Esterville, Iowa., succeeding **C. Hitchcock.** **Thomas Lee** succeeds **Mr.**

Heider as shop electrician. **A. Brashaw,** shop electrician at Shawnee, Okla., has been appointed terminal electrician at Pratt, Kans., vice **F. E. Clark** and **H. G. Martin,** terminal electrician at El Reno, Okla., has been transferred to Topeka, Kan., succeeding **F. B. O'Rourke. E. R. Wodehouse** succeeds Mr. Martin at El Reno.

Joseph Mann has been made terminal electrician on the Chicago, Rock Island & Gulf, at Delhart, Texas, succeeding **W. W. Thompson,** and **J. F. Claxton** has been made terminal electrician at Amarillo, Texas, vice **W. Burkeholder.**

J. A. Houston, trainmaster on the Dakota division of the Chicago, Rock Island & Pacific, has resigned, effective September 15, to become associated with the **Westinghouse Electric & Manufacturing Company** in the engineering department, where he will handle questions pertaining to the mechanical design of the electric locomotives for heavy freight and passenger service. Mr. Houston was born at Springfield, Mo., in 1886. After receiving the degree of mechanical engineer at Purdue University in 1911, he continued his studies at the University of Illinois, where he specialized in railway mechanical engineering for two years. He entered railway service with the St. Louis-San Francisco as a machinist's apprentice at Springfield, Mo., in 1904. While there he won the Ryerson Scholarship of the American Railway Master Mechanics' Association and in 1907 started on these studies. He continued with the Frisco during his vacations and in 1910 became assistant chief draftsman, handling test matters in the mechanical department. After graduating he entered the mechanical department of the Chicago, Rock Island & Pacific, eventually becoming special engineer on the staff of the general mechanical superintendent. In 1916, he left the mechanical department to enter the operating department as trainmaster on the Dakota division, which position he held at the time of his recent change.

TRADE PUBLICATIONS

Copper Clad Steel Company, New York, N. Y., is distributing a small, colored envelope folder in which are briefly reviewed some of the advantages obtained from the use of "Copperweld" Bond Wires.

The Ohio Brass Co., Mansfield, Ohio, in its latest O-B Bulletin discusses the subject of Electric Arc Weld Bonding with special reference to rail bonds of its own manufacture and the O-B Electric Arc Welder, describing and illustrating the various parts of this equipment.

The Fafnir Bearing Company, New Britain, Conn., in the September number of its house organ, "The Dragon," tells of a number of interesting applications of ball bearings. Among the applications cited are wheelbarrows for brickyards, line shaft bearing hanger boxes, magnets, generators and farm tractors.

Pacific Electric Welder & Mfg. Co., Renton, Washinton, is distributing an 8-page illustrated catalogue in which is described the electric spot welder manufactured by the company. The welder is classified as automatic; it is simple to use, and does not require any highly skilled mechanic for its operation.

Standard Underground Cable Company, Pittsburgh, Pa., in its September bulletin No. 740-1 illustrated and described the correct method for using "Ozite" insulating compounds in connection with Standard paper joining tubes. The necessity for making properly the splices in high voltage cables is particularly emphasized and the reasons for failures in such connections, pointed out.

The General Electric Company, Schenectady, N. Y., recently distributed in bulletin No. 48704A, which describes and illustrates the processes used in the manufacture of G. E. Insulating Compounds. The bulletin contains much data on insulating mixtures of all kinds for the wide range of application met with in electrical installation. Another bulletin, No. 44002A, by the same company treats comprehensively of rail bonds and bonding tools.

Electric Service Supplies Company, Philadelphia, Pa., recently issued from its engineering laboratories a report, known as No. 303, in which is discussed in detail the relation of Golden Glow glass headlight reflectors to the locomotive headlight question. The report presents valuable information concerning the relative performance of ground and unground reflectors, these data being in the form of curves and tables. A portion of the report shows how satisfactorily the Golden Glow reflectors meet the Interstate Commerce Commission ruling regarding the installation of electric headlights. The question of headlights is a live topic at the present time and a copy of this report should be in the hands of every electrical man associated with this particular development.

How Boston Uses the Dean Control for the operation of gate valves is told in a 4-page, 8½ in. by 11 in. illustrated paper, entitled "Extension to L Street Station, Boston," and published by the Cutler-Hammer Manufacturing Company of Milwaukee and New York. This power station extension represents the latest practice in design and will therefore be of interest to power engineers. Another bulletin recently issued by the Cutler-Hammer Company, containing 24 pages, is known as "Publication 830" and is devoted to the description and illustration of battery charging equipment for electric street vehicles, industrial trucks, battery locomotives and other secondary battery equipment. This pamphlet is 8½ in. by 11 in. in size and is well illustrated with photographs showing in detail the various parts of the equipment, as well as a number of large installations in actual service.

Uehling Instrument Company, New York, N. Y., has just issued bulletin No. 111 describing Style U Uehling CO_2 (carbon dioxide) equipment. This is a new design built in single and multiple forms, the latter serving any number of steam boilers simultaneously up to a total of six. The purpose of this equipment is to save fuel by burning it with the proper air supply. Among the notable features of the new machine are speedy action, resulting from a new form of aspirator, absence of chemical solutions, greater simplicity and the unique plan of providing an auxiliary boiler front CO_2 indicator, which guides the firemen, while the CO_2 recorder, installed in the chief engineer's or superintendent's office, makes a continuous (not intermittent) record showing all changes in boiler adjustments that are conducive to either waste or economy.

Railway Electrical Engineer

Volume 11 November, 1920 Number 11

THE ELECTRICAL ENGINEERS' CONVENTION

The officers of the Association of Railway Electrical Engineers are to be congratulated upon the well-rounded success of the 1920 convention. The attendance at the meetings was excellent, the exhibits were numerous and of high standard and the program, while somewhat shorter than previous conventions, was well-proportioned and most excellently arranged. By holding the meetings in the morning, the afternoons were left available for a more complete and careful inspection of the various equipments exhibited by the Railway Electrical Supply Manufacturers' Association. In view of this, it is safe to say that the majority of those who attended the convention were able to derive more benefit from both the committee reports and the apparatus exhibited than has been possible in many of the conventions in the past. It is to be hoped that this policy will be continued in subsequent conventions.

Among the committee reports presented at this year's convention are two subjects which have not previously been touched upon by this organization, namely, trucks and tractors and repair shop facilities. The fact that trucks and tractors are beginning to assume their rightful place in the handling of materials in railroad freight houses and shops indicates that the value of this apparatus is making itself felt. There are, however, certain phases of truck and tractor installations which require special study in order that the best results may be secured and the committee on this subject has a wonderful opportunity to make a careful and thorough study of the situation and to present to the association the valuable data which must necessarily accrue from such investigation.

The fact that the importance of electrical repair shop facilities is being more generally recognized on the railroads indicates beyond all shadow of a doubt the growing necessity for electrical equipment in connection with the steam railroad transportation business. Electric motors are being used for almost every conceivable purpose where a demand for power exists; in fact, so many of these are being used that it is no longer possible to relegate the repair of such important equipment to some out-of-the-way corner where proper facilities are wholly lacking. The excellent repair shops described in the report of the committee show beyond all doubt that recognition is being accorded to this important factor on some of the roads.

Each year has seen an increase in the number of applications of electricity in the steam railroad field so that practically today every department has been touched by one phase or another of this development. While the future cannot contain any great quantity of new applications in this field, certain it is that those applications which have already proved so successful will continue to grow and expand.

YEARLY INDEXES

The number of yearly indexes for the 1920 volume of the *Railway Electrical Engineer* will be limited. Only those subscribers who desire to bind their copies or who will have use for the yearly index will be supplied. If you desire one write to the Circulation Department of the *Railway Electrical Engineer* requesting a yearly index. These requests should be received not later than January 1, 1921.

BREAKING MORE RECORDS

The railroad employees and managements are to be congratulated upon the remarkable showing that has been made in moving freight during recent months. For three successive weeks during the early part of October more than a million cars were loaded with commercial freight each week. The figures for the last week of October were not available when this was written. For the 12 weeks ending October 23, the total revenue car loading was 11,654,567 cars, as compared with 11,291,665 during the corresponding period of 1919, and 11,431,467 in 1918.

Complete figures for the month of August have been compiled by the Bureau of Railway Economics which indicate that during that month the railroads as a whole almost made the goal of 30 tons per car, actually reaching 29.8 tons. This average has been exceeded only twice, notably in July and August, 1918, when the average carload reached 30.1 tons. During July the average miles per car per day reached 27.4 miles, which is greater than any month since July, 1917, and exceeds the average for any month during federal control. It was exceeded only in May, June and July, 1917, when the railroads were being operated under the Railroads War Board and when the average car mileage was 29, 28.4 and 28.3 respectively. With the temporary slowing down of business, the railroads may be able to take care of all of the traffic which is offered to them, provided the winter season is not too severe. There is still a great tonnage which must be moved within a reasonable period and this can only be handled successfully if the roads continue the intensive efforts that they have been recently putting forth.

No particularly new or radical methods have been introduced to make these new records. They are due to painstaking attention to detail, and enthusiasm and teamwork on the part of all of the employees. The shipper, too, has done his part, and if he understands the intent of the Transportation Act, will undoubtedly continue so to do. Getting better use from the freight cars means more efficient and economical operation. This will insure to the shipper the lowest possible rates.

STANDARD EQUIPMENT FOR ELECTRIFIED LINES

At some time in the future the question of interchangeability of equipment for the electrically operated roads in this country will have to be threshed out. An answer to this question for the English railroads has been recommended by the Advisory Committee on Electrification of Railways appointed sometime ago by the British Minister of Transport. An abstract of the first preliminary report appears elsewhere in this issue. This report recommends the adoption of direct current at voltages of 750, 1,500, or multiples of these values, with either overhead or third rail collection for future installations and also recommends the continuance of the existing 600-volt and the 1,200-volt direct current systems.

The use of electric motive power is slowly but surely increasing in this country and the ability of electrically operated roads to interchange equipment will be highly desirable if not prerequisite. We must realize, however, that railroading in the United States is a problem with greater ramifications than in England and to decide on a system before those in use have been thoroughly tried out, would not be wise. In England the electrifications have been mainly of the suburban type using multiple unit equipment and, with one exception, for passenger service. The English authorities will be commended for their forehandedness, but their decision should not be given too much weight in this country because of the different conditions involved. It may prove desirable to adopt more than one system in this country. The number of systems and the types of motive power used will eventually have to be reduced to the most practicable minimum, but there is still much work to be done in the way of development before a decision can be made.

COMPARING MODERN STEAM AND ELECTRIC LOCOMOTIVES

The relative advantages of steam and electric locomotives were discussed at a joint meeting of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Railroad Section of the A. S. M. E., held in the Engineering Society's building, New York, October 22. An abstract of the three principal papers of the discussion appears elsewhere in this issue. Both railroad and supply men took part in a lengthy discussion which amounted practically to a joint debate.

Many comparisons were made, several of which were not entirely warranted. For example, one of the speakers did not hesitate to compare the operation of modern electrical equipment on the Chicago, Milwaukee & St. Paul with the results that were obtained many years ago on that road with Prairie type of locomotives. He did admit, however, that this was not an absolutely fair comparison and said that operation with modern Mikado locomotives might show different results. He then compared electric locomotive performance with that of modern steam locomotives, but the steam men maintain that the stand-by losses and amount of coal per indicated horse power hour, which he used for arriving at his conclusions, are larger values than actually obtain in everyday operation. On the other hand, one of the advocates of steam operation was inconsiderate enough to compare the train loading on the Virginian Railway with that on the electrically operated divisions of the St. Paul. He did not draw attention to the fact that the Virginian carries bituminous coal almost exclusively, whereas the St. Paul traffic is of a very miscellaneous character not conducive to heavy train loading.

A comparison of the relative merits of steam and electric motive power involves so many factors that it is an unwieldy subject. Furthermore, it seems to be a difficult matter to find men to discuss this subject who are not ardent advocates of one or the other type of power. To the layman, the results of the meeting amount to a mass of conflicting data, but to those who have an understanding of the subject there is much to be learned by careful study of the material presented at this meeting.

NEW BOOKS

Electric Traction and Transmission Engineering. By Dr. Samuel Sheldon, professor of physics and electrical engineering, Polytechnic Institute of Brooklyn, N. Y. 308 pages, 122 illustrations, 5¾ in. x 8 in. Bound in cloth. Published by D. Van Nostrand Company, New York.

This book is designed for the use of technical students and young engineers. It covers the field of electric traction, dealing both with the urban and interurban types of equipment. The object of the author has been to present the essential details of electric traction in the most comprehensive manner, keeping constantly in mind those for whom the book was prepared.

The various factors of electrical operation, such as tractive effort, performance curves of motors, speed curves, control equipment and energy consumption have been most carefully explained. The problem of supplying the rolling stock with power has been fully taken care of in chapters dealing with the subject of power stations, both steam and hydraulic, transmission lines, sub-stations and a distribution system.

At the conclusion of each chapter a number of problems have been prepared as a drill to the work immediately preceding. In a volume of this size it is, of course, impossible to include every detail of the subject of electric traction, but the subject matter which has been presented is up-to-date and the student who follows the work conscientiously will acquire an excellent understanding of the general subject and of the problems involved in electric railway operation.

Relative Merits of Steam and Electric Traction

Many Conflicting Opinions Presented at Joint Meeting of Electrical and Mechanical Engineers

THE advantages of steam and electric locomotives were propounded by their exponents at a joint meeting of the New York Section of the American Institute of Electrical Engineers, the Metropolitan Section of the American Society of Mechanical Engineers and the Railroad Section of the American Society of Mechanical Engineers held on October 22 in the Engineering Societies building, New York. E. B. Katte, chief engineer electric traction, New York Central, presided and the meeting was opened by F. J. Sprague, Sprague Safety Control and Signal Corporation. One paper on steam locomotives and two papers on electric locomotives were presented and the papers were discussed by several railroad and railroad supply men.

Mr. Sprague outlined the history of the development of electric traction from the advent of the New York Elevated and the original Richmond street railway up to the present time as it is applied to trunk line electrification. He compared the inherent characteristics of the two types of locomotives, stating that while the one was a moving power plant, the other was but a transformer of energy and was, therefore, capable of much greater capacity. In closing he spoke as follows:

"After the practical limits of increase by machine incident to the use of steam are reached, and these will probably include a more than corresponding increase in the amount invested in motive power, there will come the time when the great increase of capacity available because of the use of electricity, plus the facts of its already successful use in many portions of the railway field, will compel the enormous increase in motive power investment inseparable from the adoption of electricity, large as it may prove, a fact which will be justified by the need existing and the results obtainable.

"I am not unmindful of the many and great difficulties in the way of accomplishment, nor would I have electrical engineers lose themselves in visionary contemplation of unobtainable commercial realities, but I may perhaps repeat the substance of the closing words of that address of 28 years ago, to which I have already referred: 'Such is the work before you, a work well meriting your best effort. Yet it is well to temper your ambitions with prudence. Limit your attempts to the solution of those problems which will promise practical benefit. Do not chase rainbows, they are beautiful and poetic but they have small place in the world's economics. This is said in no spirit of discouragement, for I yield to no man in my confidence in the future of electricity. No field is so rich, none so pregnant with great possibilities.'"

The following are abstracts of the three principal papers and the discussion.

Advantages of Electric Locomotives Have Been Greatly Overstated

By John E. Muhlfeld

Railway and Industrial Engineers, Inc.

Today, in consideration of the existing rates and regulations as established by the Interstate Commerce Commission the minimum fixed charge and the maximum operating and maintenance economy will be required on every railroad if the stock owners are to receive even a reasonable return on their investments.

In the protection and control of railroad net earnings, one of the most important factors is the kind of motive power to be used. Unfortunately, in making comparisons of the relative values of steam and electric railway power, some of the electrical engineers have frequently given out such attractive loose figures that railway managers and their engineers have often been misled into making recommendations that have later resulted in embarrassment. For example, comparisons have been made between the operations of new up-to-date electric and of obsolete steam installations. Also assumptions have been made of extraordinary steam locomotive stand-by fuel losses and of like erroneous factors.

When discussing or recommending the further electrification of the whole or any part of the steam operated railroads in the United States, the most important item involved is a correct and complete statement of facts, comparing the most up-to-date steam with similar electric operations, after which immediately come the important factors of the necessary financing and legislation.

While there is much existing steam road trackage that can and should receive first consideration as regards electrification for the purpose of eliminating gases from underground terminals and tunnels and to give relief to terminal or line traffic congestion in the vicinity of large commercial and industrial centers, it would be financial suicide to electrify immediately adjacent connecting and intermediate mileage, particularly in view of the improvements that can be made in both existing and new steam locomotives in increasing general efficiency and economy in operation and maintenance.

Before the electric locomotive can be made permissible for general application the electrical engineer must reduce first costs; promote interchangeability; provide a motor which will efficiently, economically and flexibly cover a wide range of speeds and not break down or deteriorate from overloading and heating; reduce complication, wear and corrosion in transmission and contact line apparatus; and substantially reduce the current losses between the point of power production and the locomotive drawbar. Likewise the steam railway mechanical engineers, locomotive builders and specialty manufacturers, if they are to guard the steam locomotive and continue it in its present field of usefulness, must become more active in modernization and bring about improvements that will substantially increase its capacity and thermal efficiency by the use of higher steam pressures and superheat; compounding; more efficient methods of combustion; utilization of waste exhaust steam and products of combustion heat; better distribution and use of live steam; reduction of dynamic weights; greater percentage of adhesive to total weight and a lower factor of adhesion; and by a substantial reduction in standby losses.

In order to determine the relative advantages of modern steam and electric locomotives the following may be stated as important items for consideration:

Financing. Few if any existing steam roads can justify or stand the additional capital investment required per mile of road for electrification, except for short distances under very special conditions such as prevailed on the Norfolk & Western; where the ventilation and 1.5 per cent grade of ⅝ mile single track tunnel restricted the train movements to six miles per hour on a congested traffic section of the main line, and even then only providing the fixed charges and operating expenses are not too excessive.

The immediate requirements of new money for the more urgent steam equipment and facilities needed to provide adequate, safe and expeditious rather than luxurious service in the regeneration of the railroads, is the obvious reason for the continued utilization of the over-all more economical steam operation, and only after the possibilities in this direction have been realized can any serious financial consideration be given to the proposed radical change to super-electrification.

Adaptability to Existing Trackage and Facilities. First and foremost in the advantages of a continuation of the existing improved steam locomotive for all purposes for which it is permissible, is its flexibility and adaptability to existing railroad trackage and terminal and operating facilities, and the relatively low first cost at which it can be purchased per unit of power developed for the movement of traffic. Being a self-contained mobile power plant, it is possible to quickly transfer needed or surplus power from one part of the line to another and to concentrate it when and where necessary, whereas with the electric locomotive this is impossible unless electrification extends over the entire property or the sources of power supply have almost prohibitive peak load capacity. Furthermore, the various systems of electrification do not make the interchanging of electric locomotives practicable without much non-productive first-cost, complication, and maintenance and operating expense.

Effectiveness in Increasing Track Capacity. Without a doubt electrification increases the capacity of a terminal. As already set forth, special line conditions may make electrification advisable for short distances, but results do not justify the frequent reference by electrical engineers to the weakness of steam locomotive haulage during the unprecedented cold weather in the winter of 1917-18, in that electrification would not have obviated the difficulty. If so, why did the New Haven not operate at 100 per cent of its capacity, over its electrified zone at that time? If short of locomotives or motor cars the New York Central had plenty of surplus that was not in use and which could not be utilized outside of its electric zone where it was badly needed. The probable answer is lack of interchangeability, which is still one of the most discouraging operating factors involved in any electrification scheme. This was fully brought out in the last report of the A. R. A. Committee on Design, Maintenance and Operation of Electric Rolling Stock wherein the wide variation of current generating, transmitting, distributing and contact systems, voltages, types of locomotives and of general ideas relating thereto sets forth the present undeveloped state of the art.

Furthermore, in the handling of heavy tonnage trains by the unlimited combining of electric locomotive units, the factors of peak load, transmission lines, and power plant capacity must all be considered with the probability that permissible modern steam locomotive train units can be more economically handled over dense traffic lines than the electric multiple unit super-trains. Although under the multiple unit system locomotive and train operation it is theoretically possible to provide unlimited sustained hauling capacity, at the head of the train, the tonnage to be handled without rear end or intermediate helpers is limited by the ability of the draft rigging on the cars to withstand the pull and shock, and this limitation can be readily met and exceeded in steam locomotive design and operation.

Train Speeds. The average freight car is in main line movement only about 10 per cent of its life, or 2 hr. and 24 min. out of each 24 hr. Therefore, increasing train speeds beyond established economic limits at the sacrifice of tonnage, and with an increase in fuel, track and equipment upkeep and danger of operation is not the solution of the freight traffic problem. Capital expenditures applied to the reduction of those delays which now involve over 21½ hr. per day, or about 90 per cent of the life of the car, would give much more effective and economical results.

As the electric locomotive is a constant speed machine, whether going up or down grade, and is unable to utilize its rated capacity and effectiveness through the same range of speed and tractive power variations as the more flexible steam locomotive, the latter can therefore be more efficiently operated over the continually changing up and down grades, levels, curves and tangents traversed by the average freight train in this country. With respect to passenger train service, where speed is more of a factor, the steam locomotive performance is equally satisfactory.

Fuel Consumption. Great economy in fuel consumption and cost is the principal claim for electrification and recently electrical engineers have advanced the theory that it would be possible to save at least two-thirds of the coal consumed by the existing steam locomotives and that the useful carrying capacity of existing trackage could be increased about 10 per cent by the elimination of company coal movement, if electric locomotives were substituted.

The basis for arriving at these comparative figures is so obviously ridiculous that they warrant comment only for the reason of the general publicity given. For example, for the steam operation a coal rate of 12.75 lb. per kilowatt-hour of useful work done, as measured at the driving wheel treads, or 7 lb. per kilowatt-hour (including transmission and conversion losses inherent to electrical operation) as measured at a central power station, were based on tests made in 1910 on the C. M. & St. P. of some probably long since antiquated types of saturated steam locomotives. For the electrical operation a modernized central power station coal rate of 2½ lb. per kilowatt-hour in combination with a 40-watt-hour rate at the point of delivery of the power to the railroad system for moving a gross ton-mile of passenger and freight train, was used, which would produce a movement of 1,000 average gross ton-miles for 100 lb. of coal of about 12,000 B. t. u. value per pound as fired. In arriving at these data apparently factors were overlooked or disregarded, such as; gradient and curvature; drifting train mileage; human element; the past ten years' improvement in steam locomotive boilers and machinery; that central power stations cannot be regulated to a basis of 50 per cent average load factor; and many others.

Item	Powdered coal locomotive	Hand fired locomotive
1—Total trips run (112.7 miles each)	14	10
2—Total miles run	1,578	1,127
3—Average running time (hours)	5.06	5.25
4—Average dead time (hours)	1.25	1.01
5—Average total time (hours)	6.31	6.26
6—Average speed (m. p. h.)	22.3	21.6
7—Average trailing tonnage per train	2,278	2,283
8—Average gross 1,000 ton miles	256.5	255.4
9—Average coal per gross 1,000 ton miles	82.4	114.8
10—Average superheat (degrees Fahrenheit)	223	173
11—Average coal per boiler and superheater hp. hour	3.74	4.99
12—Average B.t.u. per pound of coal as fired	12,025	11,160

THE advocates of electric traction lay particular stress on the points that their motive power will greatly increase traffic capacity and will reduce the railroad coal bill.

Mr. Shepard maintains that with present standards of train make-up, classification and terminal handling, electrification will double the capacity of any railroad and Mr. Armstrong contends that an electric locomotive will do as much useful work with one pound of coal as a Mikado steam locomotive will do with 2.37 pounds.

However, accepting the assertion that the proposed electrification will produce 1,000 gross ton-miles for an average of 40 kilowatt-hours, or 100 lb. of 12,000 B. t. u. coal, as stated and generally approved by electrical engineers, what can the modern steam locomotive do to justify its existence? The following results of dynamometer car tests, made during 1918, may be of interest The steam locomotives tested were of the ordinary superheated Mikado freight type. One locomotive was fitted for hand firing and burning coal on grates, while another was equipped with the "Lopulco" system for burning powdered coal in suspension. The tests were made in tonnage freight service handling from 2,400 to 2,600 tons east-bound and from 1850 to 2250 tons westbound on the Santa Fe main line between Ft. Madison, Iowa, and Marceline, Mo. (the profile consisting of .8 per cent ruling grades), a distance of 112.7 miles, during March and April, 1918.

It can be assumed from the foregoing that the average yearly performance will approximate 100 lb. of 12,000 B. t. u. coal per 1000 gross ton-miles, or equivalent to what we are promised for the expenditure of billions of dollars of new capital and the loss of billions of dollars' worth of investment in existing plant and equipment to inaugurate the comforts of electrification.

It is also not out of order to refer to dynamometer car tests which it is understood have been made on the New York Central, wherein on the basis of the thermal value of the coal, a single expansion superheated steam locomotive required, per drawbar horsepower hour, about 2.6 lb. of coal as compared with about 2.25 lb. for an electric locomotive.

A. Lipetz, chief of the Russian Mission of Ways of Communication, has also presented some data relating to exhaustive tests made on Russian railroads during the period 1908 to 1914, with simple and cross-compound types of steam locomotives with and without superheaters, which are of interest in this connection. The greatest fuel economy was obtained with the cross-compound superheater locomotives. In general the cross-compound locomotives showed a saving of about 17 per cent as compared with the simple, and the superheater locomotive showed a saving of about 21 per cent as compared with the saturated, while the cross compound superheater locomotives showed a combined saving of about 35 per cent as compared with the simple-saturated locomotives.

As there are now about 65,000 steam locomotives in the United States, of which probably 62,000 have simple and only 3,000 have compound cylinders, and of which total only about 25,000 are as yet equipped with superheaters, the foregoing indicates what steam locomotive fuel savings are still possible merely through the application of cross compounding or superheating, or these combined factors.

Efficiency of Locomotive Operation. The off-setting fuel and energy losses, due to standby losses in the steam operation, and decrease in efficiency on account of fluctuating loads in the electric operation must not be lost sight of. Neither should those incident to the transforming, transmission and conversion of electric current and like factors be neglected.

It is unquestionably true that when operating under ideal fixed load conditions, the central power station, either hydro-electric or steam, can produce a horsepower with less initial energy input than is possible on a steam locomotive. It is also true that the standby losses on existing steam locomotives are, in ordinary practice, a serious proportion of the total fuel consumption, but it is likewise a fact that the majority of these can be substantially reduced if not entirely overcome, by modernizing the present equipment and improving maintenance and operation which would then rob the electrical engineers of their main argument in favor of a blanket electrification.

While the electrical engineers and manufacturers in this country deserve great credit for the progress made in the development of the electric locomotive, they have as yet been unable to design one which can operate at maximum efficiency throughout its range of load. The point of maximum efficiency being well established and fixed, and the current curve on an electric motor not being flat, any over or under-load from the predetermined maximum efficiency load increased the current consumption. Furthermore, when, on account of transportation conditions, a motor is required to carry an overload for periods of five or six hours, it either breaks down due to heating or otherwise requires special power consuming auxiliaries or long rest periods for the dissipation of the heat stored within itself due to the resistance of the current through the wiring, to permit of continuous operation.

Furthermore, to produce, at various hydro-electric or steam power plants, electric current at, say, 6,600 volts a. c., step the current up to 100,000 volts a. c., connect and transmit it from 100 to 300 miles through transmission lines to switching sub-stations located approximately 30 miles apart, step down to 2,300 volts a. c., and then convert into direct current at, say, 3,000 volts for locomotive use, involves expensive lines, plants and equipment, as well as tremendous losses from the generator at the central power station to the bus bar on the direct current side of the transformer, where the current is usually metered for billing. Also the secondary system, as well as the losses through the motors and the machine friction of the electric locomotive itself, are responsible for further losses in current, all of which, after allowing for, say, 10 per cent regeneration, not only limit the capacity of the electric zone but also materially increase the arbitrary electric costs usually considered, so that it is safe to say that the actual dead loss in power from the central power station to the electric locomotive drawbar will be not less than 50 per cent.

The number of factors entering into an analysis of the net thermal efficiency of the electric locomotive, in terms of drawbar pull, are so many as to make it impossible, with the lack of dynamometer car and laboratory test data, to arrive at a figure which is not based on a number of assumptions; but as a matter of interest, assuming, that *all of the factors are affected equally* in the electric locomotive, the net thermal efficiency at the drawbar, when taking into consideration the boiler, engine, generator, step-up transformer, a. c. transmission, step-down transformer, a. c.-d. c. converter, d. c. transmission, motors, and machine efficiencies may, as representative of average existing practice, be taken as shown in Table 1.

TABLE 1—COMPARATIVE EFFICIENCIES OF ELECTRIC AND STEAM LOCOMOTIVES

ELECTRIC EQUIPMENT

Equipment	Efficiency Factors and Net Thermal Efficiency, per cent...	Load Rating, Per cent 100	75	50
Boiler	Factor	....	....	....
	Efficiency	76.7	76	72
Engine	Factor	18.25	18.29	19.17
	Efficiency	14	13.9	13.8
Generator	Factor	90	89.5	86
	Efficiency	12.6	12.44	11.88
Transformer, Step-Up	Factor	98	96	90
	Efficiency	12.34	11.93	10.67
Transmission, A.C.	Factor	90	95	97
	Efficiency	11.10	11.32	10.34
Transformer, Step-Down	Factor	98	96	90
	Efficiency	10.87	10.85	9.30
Converter, A.C. to D.C.	Factor	80	75	63
	Efficiency	8.69	8.13	3.85
Distribution, D.C.	Factor	90	95	97
	Efficiency	7.82	7.71	5.66
Motors, D.C.	Factor	91.5	90.8	89.5
	Efficiency	7.15	7.00	5.05
Machine Efficiency	Factor	81	85	90
	Efficiency	5.79	5.95	4.54

STEAM LOCOMOTIVE

Equipment	Superheated or Saturated	Efficiency Factors and Net Thermal Efficiency, per cent...	Load rating, Per cent 100	75	50
Boiler	Superheated	Factor	....	....	....
		Efficiency	42.7	54.9	65.9
	Saturated	Factor	....	....	....
		Efficiency	45.0	57.4	70.0
Cylinders	Superheated	Factor	11.9	11.0	10.5
		Efficiency	5.08	6.04	6.92
	Saturated	Factor	7.8	8.4	7.8
		Efficiency	3.51	4.82	5.46
Machine	Superheated	Factor	75	80	85
		Efficiency	3.85	4.83	5.88
	Saturated	Factor	77	80	82
		Efficiency	2.70	3.86	4.47

Comparing the electric and steam locomotive figures as illustrated, the relative percentage of power delivered at the track rails to 100 per cent B. t. u. in the coal would be:

Kind of locomotive	Net Thermal Efficiency at Load Ratings of 100 per cent	75 per cent	50 per cent
Electric	5.79	5.95	4.54
Steam, superheated	3.85	4.83	5.88
Steam, saturated	2.70	3.86	4.47

As 100 per cent load rating conditions would, in practice, occur only momentarily and as the majority of the drawbar load represents from 30 to 60 per cent of the locomotive maximum drawbar capacity, comparison should properly be made only of the net thermal efficiencies at 50 per cent load ratings.

Various dynamometer car and laboratory test performances of representative types of steam passenger and freight locomotives confirm the foregoing figures relating to steam operation. At speeds of from 15 to 75 miles per hour the existing superheated steam locomotive thermal efficiency actually ranges from 5.3 to 8.1 per cent as compared with the calculated figures of from 4.83 and 5.88 per cent for 75 and 50 per cent load ratings, respectively. Adding to this an increase of from 15 to 50 per cent in net thermal efficiency that may be produced from developments now under way, the steam locomotive of the future will be quite a respectable assembly of engineering efficiency.

Cost of Maintenance. In determining the maintenance cost of the electric locomotive the popular error is to take into account the locomotive proper, whereas a true comparison can only be made by including all corresponding elements as found in the self-contained steam locomotive which goes back to the upkeep of all facilities having to do with the utilization of the fuel or water power, including the central power station buildings; boilers; engines; conversion, transmission, distributing and contact line systems; sub-stations; track rail bonding and insulation; electric disturbance cut-outs or neutralizers; extra expense in upkeep of the electric zone trackage; and like auxiliaries and finally the electric locomotive itself.

Peak Load Conditions in Relation to Traffic Requirements. With the steam locomotive the traffic requirements are met by the distribution and utilization of the necessary number of self-contained motive power units as required, regardless as to the capacity of one or more central power stations or of any limitation in quantity, or in price, of the total available power output. The operation of one or of 500 steam locomotives at their maximum capacity at any given, or for any duration of time on a single division, is of no concern.

However, in order to meet the ideal conditions for electrification, the traffic should be uniformly spread or scattered over the 24 hr. period, whereas in the majority of cases train movement is based on traveling and shipping conditions and cannot be advanced or delayed in order to eliminate peak load conditions.

Rate of Acceleration. In order that the desired running speeds can be reached in the minimum of time after the starting of trains, the ability of a locomotive to accelerate its load rapidly is of considerable importance and in this respect the electric power has had the advantage. The steam locomotive engineer has, however, not lost sight of this fact and improvements already made in boiler and cylinder horsepower ratios, as well as developments now undergoing for the utilization of existing non-productive adhesive weight and to increase the coefficient of friction between the propelling wheels and the track rails, will enable the steam locomotive to duplicate the performance of its electric competitor in this regard.

Train Braking. Since the development of regenerative braking with the electric locomotive, great emphasis has been laid on the increased security of operation over heavy grade lines due to the ability of the locomotive to hold the train under complete and positive control on the down grade without brakes, by temporarily converting the main motors into generators to produce electricity which is returned to the line for use by some other locomotive in pulling a train. Considerable attention has also been directed to the saving brought about through the elimination of the ordinary air braking on such down grades.

ELECTRICAL engineers in this country were long ago convinced that many more railroads should be electrified. Effort is now being made by advocates of electrification to convince the public of the need for adopting electric tractions. The most important task is to convince the railroad executive who was brought up with and educated to use steam power that electrification will solve his own particular problem. A few have already decided it can be applied to certain divisions profitably and will adopt it when capital can be secured.

While the regenerative system of braking can no doubt be developed to the point where it can be safely used, in view of the recent serious accident on the St. Paul, due to the failure of the regenerative brake control, just what economy will result is problematical. When the power so generated cannot be directly used by another pulling locomotive on the line, it must be otherwise absorbed, and it remains for the electrical engineers to prove just how much of it is lost in conversion or by absorption and the resulting net gain as compared with the investment, fixed charge and upkeep and operating cost for the equipment involved.

Effect of Weather Condition. Even though the full steaming capacity, horsepower and drawbar pull of a modern steam locomotive can be developed during cold weather conditions, there are the factors of radiation and freezing to be reckoned with, which give the electric locomotive the advantage in winter, particularly, as its effectiveness is greater on account of the lesser tendency for the motors to overheat. This winter advantage, however, is largely overbalanced during the summer when the main motors heat, especially under overloads, and require cooling at terminals or otherwise overheat and result in insulation break-downs or burn-outs, or other troubles.

Road Delays and Tie-Up. While the electric locomotive has the advantage of not being required to take on fuel and water, except for the operation of steam heating equipment for passenger trains, with the increased capacity of the modern steam locomotive tenders, and the lower water and fuel rates per drawbar horsepower developed, the delays due to taking on these supplies have been greatly reduced and need not be srious.

Barring collisions, wrecks and like accidents not due to the system of motive power in use, steam operation is not susceptible to complete tie-ups as is the case with electrification, where short circuits or failures occur due to rains, floods, storms and like causes, and as the result of motor, wiring and insulation heating, deterioration and break-downs, as the individual mobility of each piece of motive power enables quick relief.

Terminal Delays. The examination of reports of a dense heavy freight traffic railroad in the Eastern District shows the time of its steam locomotive for a recent two months' period distributed as shown in the small type below:

There is no doubt that the electric has an advantage over the steam locomotive as regards time required for periodical boiler work, fire cleaning and rebuilding, fueling and watering except where fuel oil is used, but where terminal delays occur due to waiting for trains, such as the foregoing statement set forth, the time required for such work does not become an expensive determining factor in the daily average miles to be obtained per locomotive. Also the fact that the electric locomotive, cannot, without terminal rest periods or otherwise the consumption of power to operate auxiliaries, operate at its maximum capacity must not be overlooked. Furthermore, many improvements in the fuel and ash handling and combustion equipment of the steam locomotive using coal are now in process and terminal delays due to these causes are annually being reduced by improved means and methods.

1—In road service	50	per cent of total time
2—At terminals waiting trains and otherwise in hands of Transportation Department	26.4	per cent of total time
3—At terminals in hands of Mechanical Department	23.6	per cent of total time

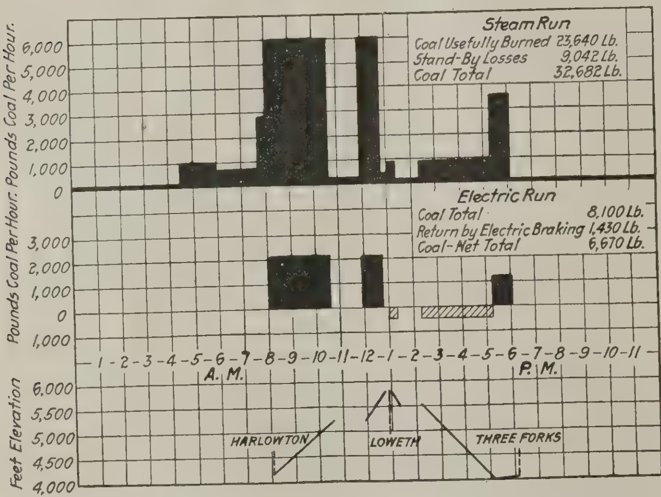
Hazards. With the establishing of more scientific and careful methods of designing, testing and inspection, and the more extended use of safety appliances, the failures of steam locomotive boilers and machinery, particularly those resulting in personal injury, are relatively low as compared with the work performed. It is, therefore, doubtful if there is any greater proportion of risk from the steam locomotive in that regard than from electrocution and other attendant dangers from high voltage electrification.

Fourteen Points for Electrification

By A. H. Armstrong
Chairman, Electrification Committee, General Electric Company

A comparison of the modern steam and electric locomotive leads immediately to a discussion of the relative fitness of the two types of motive power to meet service conditions. At present railway practice has closely followed steam engine development, but are we not justified in looking at the transportation problem from the broader standpoint of a more powerful and adaptable type of motive power?

Place at the disposal of an experienced train despatcher a locomotive capable of hauling any train weight that modern or improved draft gear can stand, at any speed permitted by track alinement regardless of ruling grade or climatic conditions, that can be run continuously for a thousand miles with no attention but that of the several operating crews, and witness what he can accomplish in his all-important task of expediting freight movement. It is not merely a question of replacing a Mikado or Mallet by an electric locomotive of equal capacity. The economies thus effected are in many instances not sufficient in themselves to justify a material increase in capital account. The paramount need of our railways today is improved service and this can be brought about by introducing the more powerful, flexible and efficient electric locomotive. Marked changes in present railway practice will undoubtedly follow the adoption of a type of motive power that is free from many of the limitations of the steam engine. As this touches upon the inherent possibilities of steam and electric locomotives, some of the fundamental characteristics of each are but too briefly discussed herewith.



Coal Record on a Basis of 1,000 Gross Tons Moved for Steam and Electric Runs from Harlowton to Three Forks, Mont.

Owing to handicap of precedent and prejudice, electricity must take up the railway problem where steam leaves off. In other words the proof is up to the electrical engineer proposing any marked departure from commonly accepted standards as established by long years of steam engine railroading. Thus while a maximum standing load of 60,000 lbs. per axle has been generally accepted for steam engines, it is well known that an impact of at least 30 per cent in excess of this figure is delivered to rail and bridges due to unbalanced forces at speed. Impact tests taken on electric locomotives of proper design disclose the feasibility of adopting a materially higher limiting weight per axle than 60,000 lbs. without exceeding the destructive effect on track and road bed now experienced with steam engines. However, owing to the flexibility of electric locomotive design, there is no immediate need of exceeding present steam practice in this respect, although this and other reserves may be called upon in the future.

Accepting the Mikado and Mallet as the highest developments of steam road and helper engines for freight service, the following general comparison is drawn with an electric locomotive that it is entirely practicable to build without in any respect going beyond the experience embodied in locomotives now operating successfully.

Comparison Steam and Electric Locomotives

	Mikado	Mallet	Electric
Type	2-8-2	2-8-8-2	6-8-8-6
Weight per driving axle	60,000 lb.	60,000 lb.	60,000 lb.
Number driving axles	4	8	12
Total weight on drivers	240,000 lb.	480,000 lb.	720,000 lb.
Total weight loco. and tender	480,000 lb.	800,000 lb.	780,000 lb.
Trac. eff. at 18 per cent coef.	43,200 lb.	86,400 lb.	129,600 lb.
Gross tons 2 per cent grade	940	1,880	2,820
Trailing tons 2 per cent grade	693	1,495	2,430
Speed on 2 per cent grade	14 m.p.h.	9 m.p.h.	16 m.p.h.
H.P. at driver rims	1,620	2,080	5,570
I. H. P. at 80 per cent eff.	2,030	2,600	.....
Trailing ton miles per hour on 2 per cent gradient	9,700	13,500	38,800

The above analysis brings out the fact that to equal the hourly ton mile performance of one electric locomotive it would require three and four engine crews respectively for the Mallet and Mikado types. In view of the facts, it is a modest claim to make, therefore, that the daily tonnage capacity of single track mountain grade divisions will be increased fully 50 per cent over possible steam engine performance by the adoption of the electric locomotive.

Regenerative Braking

The hazard of mountain operation is greatest on down grades although the perfection of automatic air brakes has done much to modify its dangers. It is left to electricity, however, to add the completing touch to the safe control of descending trains by supplying regenerative electric braking. Not only are air brakes entirely relieved and held in reserve by this device but the potential energy in the descending train is actually converted into electricity which is transmitted through the trolley to the aid of the nearest train demanding power. Aside from the power returned from this source (14 per cent of the total on the Chicago, Milwaukee and St. Paul Railway) the chief advantage of electric braking lies in its assurance of greater safety and higher speeds permitted on down grades.

The heat now wasted in raising brake shoes and wheel rims often to a red heat is returned to the trolley system and becomes an asset instead of a likely cause of derailment.

Cost of Maintenance

Probably in no one respect does the electric locomotive show greater advantage over the steam engine than in cost of maintenance. Electric locomotives are now being operated 3,000 miles between inspections on at least two electrified railways and the above figures are available:

ELECTRIC LOCOMOTIVE MAINTENANCE, YEAR 1919

	N. Y. C.	C. M. & St. P.	B, A. & P.
Number locomotives owned....	73	45	28
Locomotive weight, tons......	118	290	84
Annual mileage	1,946,879	2,321,148	566,977
Repairs per mile..............	6.39 cents	14.65 cents	6.48 cents

On the basis of pre-war prices, maintenance costs were approximately 60 per cent of above figures given for the year 1919. In contrast, it can be stated that the present cost of maintaining a type 2-8-8-2 Mallet is fully 60 cents per engine mile, without including many miscellaneous charges not shared by the electric locomotive. Possibly more direct comparison may be better drawn by expressing maintenance in terms of driver weight.

STEAM AND ELECTRIC REPAIRS

	Steam Mallet	C. M. & St. P. Electric
Cost repairs per mile...............	60 cents	14.65 cents
Weight on drivers..................	240 tons	225 tons
Cost, repairs per 100 tons loco. wt. on drivers	25 cents	6.52 cents

Including all engine service charges, the facts available give foundation for the claim that electric locomotives of the largest type can be maintained for 25 to 30 per cent of the upkeep cost of steam engines operating in similar service.

THE steam locomotive advocates maintain that the electric locomotive must provide for interchangeability and that the advocates of electric traction must be able to show a substantial return on the additional investment necessary for electrification if they expect the railroads to adopt it for anything but tunnel and terminal service and for short distances under very special conditions. In speaking of the coal saving claims made by the electrical men Mr. Muhlfeld says that the basis for arriving at these figures is obviously ridiculous.

Fuel Saving

Much has been written on the subject of fuel saving effected by steam railway electrification. The estimates of electric engineers have been called extravagant by steam engine advocates, who in turn have been charged with an incomplete knowledge of all the facts available. Fuel economy figured prominently among the several reasons leading up to the replacement of the steam engine on the Chicago, Milwaukee and St. Paul Railway as brought out by a careful analysis of the performance of the steam engines then in service. The results of the many tests are doubly interesting when compared with the daily performance of the present electric locomotives now running over the same tracks and operated in some instances by the same engine crews. Although the steam engines tested may now perhaps be considered obsolete and not within the scope of this discussion of the modern engine, nevertheless it is not without value to compare the results of steam and electric locomotives operating over such long distances under identical conditions. The following data are therefore submitted as applying to a particular equipment only. No claim is made that it is representative of the best modern steam engine performance, although many thousands of steam engines still in operation will show no greater economies than those given in the following table. The general data applying to the steam and electric locomotives tested are as follows:

C. M. & ST. P. TESTS—LOCOMOTIVE DATA

	Steam	Electric
Type	2-6-2	4-4-4-4-4-4
Weight of engine....................	206,000 lbs.	568,000 lbs.
Weight of tender....................	154,000 lbs.	....
Weight total engine and tender......	360,000 lbs.	568,000 lbs.
Weight on drivers...................	152,000 lbs.	450,000 lbs.
Ratio driver weight to total.........	42.2 per cent	79.3 per cent
Rigid wheel base	13 ft.	10 ft. 6 in.
Diameter drivers	63 in.	52 in.
Cylinders	21 in. x 28 in.	....
Boiler pressure.....................	200 lbs.	....
Heating surface	2,346 sq. ft.	....
Grate area	45 sq. ft.	....
Water capacity	8,000 gals.	....
Coal capacity	14 tons	....

The run of 111.1 miles from Harlowton, elevation 4,162 ft., to Three Forks, elevation 4,066 ft., over the Belt Mountain Divide at Loweth, elevation 5,789 ft., was made by steam with 871 ton trailing in 26 cars and by electric locomotive hauling 64 cars weighing 2,762 tons. In order to picture a direct comparison of the results of the steam and electric runs, all test data are reduced to a common basis of 1,000 gross tons moved, this unit of measurement including the locomotive and tender weight. The running speed of the electric train was but slightly higher than the steam and the additional correction in the power demand rate of the former is made proportional to the lower speed. Both runs are therefore shown as made in identical time on the basis of 1,000 total gross tons moved in each instance. The fuel furnishing power to the steam train was coal having the analysis shown below.

Electric power was furnished by water and hence no direct coal equivalent is provided by the test result. To afford a common basis of comparison, however, a single assumption seems permissible and a rate of 2½ lbs. of coal per kilowatt hour is taken as representative of fair electric power station practice. Coal burned under the steam engine boiler was determined by weighing at the end of the run and by detailed record of scoops en route. Power input to the electric locomotive was obtained by carefully calibrated recording watt meters as well as curve drawing volt and ampere meters. These values of locomotive input were raised to the value of three phase power purchased in the ratio of 68 per cent given by R. Beeuwkes in his A. I. E. E. Paper of July 21, 1920, and the kilowatt

COAL ANALYSIS

Fixed Carbon	Volatile Carbon	Ash	Moisture	B.t.u's
47.99	38.98	8.35	4.68	11,793

hours so obtained reduced to coal equivalent in the ratio of 2½ lb. coal per kilowatt hour.

To assist in arriving at a truer comparison of modern steam and electric locomotive operation, a further analysis of the above test is enlightening. The commonly used unit measurement of pounds of coal per 1,000 ton miles is at best a very rough and unstable comparison of steam engine runs over different profiles, variable quality of fuel and operating conditions. For illustration, the following data may apply:

POUNDS COAL PER 1,000 TON MILES

	2 per cent grade	Level track
Hp. hr. at driver rims	123	18.8
Ind. hp. hr. at 80 per cent eff	154	23.5
Lb. water per i. hp. hr	20	16
Lb. water per lb. of coal	6	8
Lb. coal per i. hp. hr	3.33	2
Lb. coal per 1,000 ton miles	513	47
Lb. coal per 1,000 ton miles trailing	650	50.5

Pounds coal per gross 1,000 ton miles may thus vary from 650 to 50.5 according to gradient and with no standby losses whatever included. The boiler must be kept hot at all times, however, and fully 33 per cent can safely be added to the above figures to include the inevitable standby losses inherent to steam engine operation. Except over very long runs with terminals at the same elevation it seems hardly possible therefore to accurately compare engine performance over different profiles by such a variable unit as pounds coal per 1,000 ton mile.

A truer understanding of what takes place under the engine boiler may be shown by continuous records of coal burned, tons moved, profile, delays, etc., all reduced to pounds of coal burned per useful H. P. Hr. work done at the driver rims with segregation of the many standby losses.

ANALYSIS STEAM AND ELECTRIC RUNS, HARLOWTON-THREE FORKS, PER 1,000 TONS MOVED

	Steam	Electric
Kw. hr. at driver rims	2,038	2,038
Hp. hr. at driver rims	2,625	2,625
Coal per hp. hr. driver rims	9.02 lb.	*3.09 lb.
Credit regenerative braking	.....	.55 lb.
Standby losses, 27½ per cent	2.47 lb.	.....
Total coal per rim hp. hr	11.49 lb.	2.54 lb.

* Measured at power house and includes locomotive losses and 32 per cent transmission and conversion loss.

Under the same conditions a modern engine would undoubtedly have consumed much less than 9.02 lb. coal (11793 B. T. U.'s) while doing work measured at the driver rim. The addition of super-heaters gives greater output and economy while mechanical stokers add output only and, it is claimed, at some expense in economy over good hand firing. However efficient the power plant on wheels may reasonably be developed without too seriously interfering with the sole purpose of the steam engine, the hauling of trains, it can never approach the fuel economies of modern turbine generating stations. Whatever transmission and conversion losses are interposed between power house and electric locomotive are more than compensated for by the improvement in the load factor resulting from averaging demands of individual locomotives.

The table in the next column is based upon actual electric locomotive performance, Harlowton-Three Forks, coal taken at 2½ lb. per kilowatt hour at assumed steam power station. Steam engine values are based upon the known working efficiency of a Mikado equipped with superheaters but penalized with the same standby losses actually determined with simple engine tested Harlowton-Three Forks. A test run from Harlowton to Three Forks with a modern Mikado engine hauling 1,420 tons may possibly show a lower average fuel rate than 3 lb. per I. H. P. Hr. at drivers, less standby waste than 9,042 lb. coal, but the average annual performance of many such engines would be most excellent if it reached the net figure arrived at of 5.9 lb. coal per actual H. P. Hr. work performed at drivers. The electric run, however, is being duplicated daily, as to relation between Kw. Hrs. and ton miles and it is just this reliability of electric operation that may at times give rise to misunderstanding in the comparison of steam and electric data.

THEORETICAL COMPARISON MODERN STEAM AND ELECTRIC LOCOMOTIVES, HARLOWTON-THREE FORKS

	Mikado	Electric
Type	2-8-2	4-4-4-4-4-4
Wt. on drivers	240,000 lb.	450.000 lb.
Wt. engine and tender	480,000 lb.	568,000 lb.
Trac. eff., 18 per cent coef	43,200 lb.	81,000 lb.
Trailing ton, 1 per cent grade	1,420	2,836
Hp. hr. at driver rims	4,360	8,200
Coal per ind. hp. hr	3	....
Coal per driver hp. hr	3.75	....
Standby loss—test result	9,042 lb.	....
Standby loss per hp. hr	2.15 lb.	....
Total coal per driver hp. hr	5.90 lb.	....
Coal at power house, kw. hr	....	2.5 lb.
Coal at power house, hp. hr	....	1.86 lb.
Coal at loco. driver, hp. hr	....	3.09 lb.
Coal credit due regeneration	....	.55 lb.
Net coal at driver hp. hr	5.90 lb.	2.54 lb.
Total net coal	24.800 lb.	20,900 lb.
1,000 trailing ton miles	157,500	314,000
Coal per 1,000 ton miles	158 lb.	66.7 lb.
Ratio coal burned	2.37	1

Comparative Cost

The superior operating advantages of the electric locomotive are admitted by many who believe the first cost to be prohibitive, largely due to the trolley construction, copper feeders, substations, transmission lines, etc., necessary to complete the electrification picture. It is true that such auxiliaries add an amount that may equal the electric locomotive expense and the task of proving the electric case is not made easier by the fact that steam engine facilities are already installed and may have little or no salvage value to offset new capital charge for electrification.

Comparing the cost of equivalent steam and electric motive power, it is apparent that on the basis of the same unit prices for labor and material, the first cost is approximately the same. While electric locomotives cost possibly 50 per cent more than steam for equal driver weight, the smaller number required to haul equal tonnage may quite offset this handicap, especially with quantity production of electric locomotives of standard design.

The steam engine also demands a formidable array of facilities peculiar to itself. This expense covers fuel and water stations, shops and engine houses, shop machinery, turn tables, ash pits, etc.

Summary

Some of the principal advantages claimed for the electric as compared to the steam locomotive may be briefly stated as follows:

1—No structural limits restricting tractive effort and speed of electric locomotive than can be handled by one operator.

2—Practical elimination of ruling grades by reason of the enormously powerful electric locomotives available.

3—Reduction of down grade dangers by using regenerative electric braking.

4—Very large reduction in cost of locomotive maintenance.

5—Very large saving of fuel, estimated as two-thirds the total now burned on steam engines in operation.

6—Conservation of our natural resources by utilizing water power where available.

7—Material reduction in engine and train crew expense by reason of higher speeds and greater hauling capacity.

8—Increased valuation of terminal real estate following electrification.

9—Increased reliability of operation.

10—Material reduction in operating expense due to elimination of steam engine tenders and most of the company coal movement, the two together expressed in ton miles approximating nearly 20 per cent of present gross revenue ton mileage.

11—Large reduction in effect of climatic conditions upon train operation.

12—Postponement of immediate necessity for constructing additional tracks on congested divisions.

13—Attractive return on cost of electrification by reason of direct and indirect operating savings effected.

14—Far reaching improvements in operation that may revolutionize present methods of steam railroading.

Electric Motive Power for Traffic Demands of Tomorrow

By F. H. Shepard

Director of Heavy Traction, Westinghouse Electric & Manufacturing Co.

Despite the title of this evening's papers and discussion, I assume that the purpose of our meeting is to develop more interest and understanding as to the position of the most recent steam locomotive and that as well for the electric locomotive. The steam locomotive is a marvelous machine, representing to a wonderful degree the combination of designers' skill and years of experience. The electric locomotive, on the other hand, while a notable machine, should, in its present service, be taken as indicative only of what may be accomplished in the future.

I am one of those who believe that the transportation problem is about the most serious one which now confronts the American people. For a number of reasons, for only part of which the railroads are responsible, provision for the movement of railroad traffic has fallen far behind the productive capacity and needs of the country today. At the same time, the demand for traffic movement will undoubtedly be doubled in about twelve years. So the question arises, what are we going to do, and how are we going to do it?

The limit to physical expansion of railroad line and of terminals has been just about reached in many cases, on account of both the prohibitive cost and the efficiency of terminals of unworkable size. A large measure of relief can still be secured by line and terminal revisions and improvements; but when the inevitable increase in the demand for traffic movement of the future is considered, these improvements savor, more or less, of expedients to secure relief which can only be temporary and very limited in degree.

With the present standards of train make-up, classification and terminal handling, electrification will double the capacity of any railroad. With the better equipment we can expect in the future, together with the evolution of improved methods of operation contingent on electric power, this capacity should be doubled again, thus securing four times the present capacity. This should certainly be accepted as vision of the future, and why not our aim? Unless some broad and consistent program is embraced, the situation, which is serious indeed today, may well be calamitous tomorrow.

The electric locomotive has generally, thus far, been a mere substitute for the steam locomotive, although, in some cases, due to the greater power of the electric locomotives, there has been a modification of the handling of traffic.

Two conspicuous cases of this have been the Norfolk & Western and the Chicago, Milwaukee & St. Paul. In the case of the Norfolk & Western, two electrics handle the same train as was formerly handled by three Mallet engines, but at twice the speed. In this operation, owing to the great increase in hours of road service as well, one electric locomotive is the practical equivalent of four of the Mallet engines replaced.

On the Chicago, Milwaukee & St. Paul, the notable change has been the elimination of intermediate terminals on the electrified section between Harlowton, Montana, and Avery, Idaho, 440 miles long. There is at present a single intermediate engine terminal, but the latest passenger locomotives are detached from trains at this terminal for inspection and work only, which takes place about once in each eight or ten trips. On regular schedule, these engines make a run of 440 miles each day, being taken off for inspection at Deer Lodge after mileage varying from three to five thousand miles. On occasion, when, due to a schedule derangement, engines have been maintained in continuous road service for periods of thirty hours or more, for a full day of twenty-four hours, mileage records of up to 766 miles in this mountain service have been established. These records are truly indicative of what may be expected with electric power.

With the retirement of the lighter and weaker car equipments, a material increase in the weight of trains will be realized. Without the limitation in train speed commonly accepted as a handicap to operation of tonnage trains, who can say what the limit to train load will be with electric power? In fact, the character of railroad operation which may be secured with electric power has not yet been visualized. Every other industry that has been electrified has experienced a revolution in methods and service due to electrification. This should be equally true in the case of the movement of our railroad traffic.

Our present methods have been built up entirely under the necessities and limitations of the steam locomotive. This is evidenced by the existence of intermediate terminals at the ends of all the so-called engine districts, where all traffic halts. Again, the steam locomotive requires attention en route, needs supplies of water and coal, and, because of its slow movement when hauling our present tonnage trains, it is frequently sidetracked for superior trains, and thus there are more and still more halts to traffic.

Car inspection now takes place at the terminus of each engine district. If, under condition of electric operation, the engine district can be increased to 200, 400 or even 500 miles, is there any good reason why car inspection should not be eliminated at the present intermediate terminals? In fact, is not the general standard of maintenance of equipment of doubtful value on the present basis of inspection at each 100 mile interval? Cars in subway service, which is certainly full of potential hazard, are economically and reliably maintained through inspection at intervals of one to three thousand miles. The elimination of these intermediate terminals, with the resultant necessity of keeping the train moving on the main line, would secure an enormous increase in miles per car with a corresponding saving in equipment.

Furthermore, with the dispatch obtained in handling trains, movement could be so marshalled and scheduled that the necessity of storing goods at terminals to protect exports and local consumption would be largely eliminated, and terminals would then become in fact, as in fiction, gateways open instead of closed.

Coming now to the comparative performance of steam and electric locomotives, it is important to bear in mind their fundamental difference—the one, a generator of power, and the other a transformer of power. The generation of power in central stations is surrounded with many refinements, and in the consumption of coal, there is every opportunity for skillful handling and supervision, so that the thermal efficiency of a modern central station is relatively high and is also continuously maintained. With the steam locomotive, on the other hand, the thermal efficiency is dependent not alone upon the design of the locomotive, but the manner in which it is worked, its condition, which differs widely from the best, and finally by the skill in firing. The electric locomotive, on the other hand, consumes power only when in service, and works at any load at its designed efficiency. The average performance, in the case of the electric, approximates the maximum in efficiency, while the steam, on average performance, will differ widely therefrom.

We can therefore hardly expect that with the best steam locomotives the average coal consumption will be equal to twice the coal rate for the same work performed by electric locomotives with steam generated power. Obviously, with hydro-electric generation, the saving in fuel is complete. There is further economy due to the lesser work performed, because the electric locomotive does not have to trail supplies of fuel and water, nor is there need for the hauling of coal to points of local supply, which from the nature of things will always be greater than hauling to electric central stations.

There are a considerable number of different designs of electric locomotives all in successful operation, and each possessing certain advantageous features. Further experience will, undoubtedly, result in the survival of common types for the different classes of service. The great latitude with which electric locomotives can be designed, while fundamentally most desirable, is in itself at the present time somewhat of a handicap. This is now the subject of intensive analysis and this study is undoubtedly developing, as well, a better knowledge of the running characteristics of the steam locomotive.

To state the case briefly, we are all interested in the transportation problem. Electrification is bound to be the most potent factor for its relief. We should therefore invite and embrace closest co-operation with the engineering and mechanical skill which has been so productive in the steam locomotive field.

Discussion

The discussion of the principal papers took the form of reading prepared discussions only and due to the lateness of the hour some of these were not presented or were given in brief. No one offered to start an open discussion when it was suggested by the chairman.

Sounder Bases for Comparison Needed

H. B. Oatley, chief engineer, Locomotive Superheater Company, stated that while both electric and steam locomotives were undoubtedly able to stand on their own merits, that it was futile to discuss these merits without some idea of what the return on the capital investment will be. This was brought out in view of the difficulties encountered by the railroads in obtaining capital. Modern electric locomotives, he said, must be compared with modern steam locomotives, the stand-by fuel losses of steam locomotives should be compared with similar losses in the power plant and losses inherent to the transmission and transformation of electric power and costs of steam engines, roundhouses, coaling and water facilities, etc., compared with costs of electric locomotives with the necessary power houses, transmission lines, substations and distribution systems.

Adoption of Electric Traction Has Been Slow

The high points of the discussion presented by F. J. Cole, chief consulting engineer, American Locomotive Company, are summed up in the following: In the 27 years since the building of the first electric locomotive for operation of the tunnel into Baltimore, only about one per cent of the steam locomotives in this country have been superseded by electrics. Advocates of electric traction fail to produce complete financial statements of installations made. Many ill-considered electric suburban lines have been abandoned. Electrically operated roads must have a large excess of power station capacity. A steam locomotive is a more flexible unit than an electric locomotive and a steam-operated road is not subject to tie-ups due to burned out cables, blow-outs, etc. Much of the fuel economy claims made for electric operation are based on unwarranted assumptions.

Railroad Facilities Must Keep Pace With Development of Nation

The thought was brought out by C. H. Quinn, chief electrical engineer (N. & W.), that if we are to maintain our standing in the commercial world, our railroad facilities must go forward and keep pace with the commercial development of the nation and that for this reason effort should be concentrated on the development of freight locomotives which can meet coming requirements. Freight car capacities, he showed, have increased 100 per cent during the past ten years, while steam locomotive capacities have increased only 10 per cent. By comparing fuel consumption of the electrified division of the Norfolk & Western with tests made on modernized Mallet engines under similar operating conditions, Mr. Quinn showed a fuel saving of 29.3 per cent in favor of electric operation. In answer to a query on regenerative braking, it was pointed out that during the past five years twenty thousand 3,250-ton trains have been taken down a 2.3 per cent grade, using only regenerative braking, without a single failure.

Fuel Economy on the New Haven

A. L. Ralston, mechanical superintendent, (N. Y., N. H. & H.) compared the thermal efficiency of the 3,000-volt direct current system with the efficiency of the electric locomotive as given in Mr. Muhlfeld's paper. It is stated that on the New Haven, the efficiency at full load was 8 per cent; at 75 per cent load, 7.8 per cent; and at 50 per cent, 7.4 per cent. To prove greater reliability of electric service, he cited the fact that there was only one failure for every 21,000 miles run by electric locomotives and a failure for every 4,000 miles run by steam locomotives. He stated that the records of the New Haven showed that in slow freight service, approximately 25 kw. hours were consumed per 1,000 gross ton miles in freight service. The coal per kw. hour averaged 2.92 lb. and the line loss was 7.1 per cent. The fuel consumption in passenger service was 9.3 lb. per car mile on the electric division while the average for steam operation on the New Haven was 19.3 lb. per car mile. With coal costing $5.00 a ton, the net saving through electrification was $393,000 a year.

In freight service, electric locomotives consumed 84 lb. of coal per 1,000 gross ton miles while steam locomotives averaged 199 lb., the saving in this service being $268,000. In switching service, the consumption of electric locomotives was 38.3 lb. per mile and for steam operation, 106.8 lb. per mile, a saving of $94,000. The electrification was therefore responsible for a gross saving in the cost of fuel amounting to $755,000 annually.

Electrical Exponents Figures Do Not Agree With Facts

The discussion presented by F. H. Hardin, chief engineer of motive power, (N. Y. C.) took the form of a criticism of the papers presented by Mr. Armstrong and Mr. Shepard. In determining the desirability of electrifying, he said, the matter of present costs and the situation 15 or 20 years hence are of utmost importance. Wheel and rail wear, he pointed out, must be considered as well as weight per axle and electric as well as steam locomotives must have back shop facilities. Figures shown on the maintenance costs of New York Central Mallet locomotives, including shop and engine-house repairs, were from 24 to 37 cents per mile as against the estimate of 60 cents offered by Mr. Armstrong, and Mikado locomotives on the N. Y. C. show a fuel consumption of 125 to 130 lb. of coal per 1,000 gross ton-miles as against the estimate made by Mr. Armstrong of 158. On speaking of Mr. Shepard's statement that electrification might quadruple the present railroad capacity, Mr. Hardin said that the electrification is only one factor, and perhaps not the greatest, of what Mr. Shepard sees in the future.

Steam Advocates Apparently Do Not Appreciate Conditions on the St. Paul

R. Beeuwkes, electrical engineer, (C. M. & St. P.) submitted a discussion criticizing the paper presented by Mr. Muhlfeld. The nature of the more pointed criticisms were about as follows: The paper captioned "Conclusions" contains statements of so general a character as not to permit of profitable argument. The "Virginian Steam Articulated" locomotive cannot justifiably be compared with the St. Paul electric locomotives as each is designed for an entirely different service and operates under entirely different conditions. Fuel economy, while important, is hardly the most important claim for electrification and its importance will vary in different cases. Decreased cost of engine repairs, enginehouse expense, train and enginemen's wages and increased ton-mile capacity of locomotives are of more importance. Motors can carry overloads —exert abnormal traction efforts—for considerable periods of time without injury, whereas the steam locomotive has a well defined maximum tractive capacity, depending upon the steam pressure at which it is supplied. Ease of starting trains is a feature of electrical operation which is so noticeable that even those not particularly interested in the matter note and remark about it. Starting each car successively, as spoken of in Mr. Muhlfeld's paper, does not apply in the case of a train on a mountain grade. The runway accident on the St. Paul was in no way an electrical failure.

In conclusion Mr. Beeuwkes spoke as follows: "Frequent references are made in the paper to improvements which are being or can be made in steam locomotives and steam operation which will make the average steam locomotive compare favorably in its performance with the electric locomotive. Steam locomotives have been used for a great many years and the electric locomotive is comparatively new. Is it too much to expect that the electric locomotive and electrical operation will also be progressing while the steam locomotive and steam operation are trying to catch up?"

Electric Operation Does Not Save Coal

The opinion was expressed by W. F. Kiesel, Jr., mechanical engineer of the Pennsylvania, that electric operation does not save coal and he produced figures obtained from locomotive tests to substantiate his opinion. Referring to Mr. Armstrong's paper he spoke as follows: "Two statements in the fuel comparison deserve some analysis. The standby losses for steam locomotives are given as 9,042 lb. of coal. The regenerative braking on the electric locomotive is credited with a saving of 1,430 lb. of coal. About half, or 4,595 lb. of coal, of the standby losses are for making fire and drifting, which is high. The coal used for making fire is not all loss.

"As to regeneration returning 18 per cent of current used back into the line, that appears high, and leads to the suspicion that Mr. Armstrong uses a comparison between a very bad steam operating condition and a very good electric operating condition, which is not representative of averages.

"At present steam locomotive standby losses are high, but when railroads get back to normal these losses will be materially reduced, and the average will no doubt be less than 15 per cent of the coal used. Regeneration may be a slight factor, but it will be nearly negligible in averages."

He also said that for either steam or electric operation the length of divisions and locations of terminals are governed by other than locomotive limitations.

Ask the Man Who Owns One

W. L. Bean, assistant general mechanical superintendent, while speaking for the steam men, presented an unbiased discussion based largely on his own experience. The following is an abstract of his remarks:

The prime factor to be considered in any engineering enterprise of commercial nature is the economic result of the entire specific project. Results of sub-projects in themselves are important and consideration sometimes of a multitude of factors of minor or more than minor nature must be sufficient, even to the last detail, but partisanship in championing some of the sub-factors to the exclusion of others is undesirable and of course does not represent the best of engineering procedure.

It must be conceded broadly that electrical operation requires less coal per unit of traffic handled than steam operation. How much less depends on the specific conditions.

Likewise, the mileage per unit of electric equipment is ordinarily greater per unit of time. On one largely electrified road, express locomotives average 27 per cent more miles per day per locomotive owned than steam power in similar service. However, the first cost of the electric engines per unit of capacity was 84 per cent greater than in the case of steam. Therefore, the fixed charges are greater for the electric engine per unit of service.

A few words respecting comparative flexibility, especially in service of a character which demands it, may be of interest. A certain modern passenger electric locomotive will handle a heavy train of Pullmans at high speed on a through run with few stops such as would require a modern Pacific type steam engine of about 43,000 lb. tractive effort. However, to operate the electric engine in heavy local service over the same distance is impossible because of the heating caused by frequent starting. In such service, the maximum train which can be handled by the electric locomotive can only approximate what can be handled by a steam engine of about 30,000 pounds tractive effort.

There is not much elaboration of the fact that an inconsiderate or over-ambitious yardmaster, may overload the electric engine and that machine, possibly in sympathetic endeavor to live up to the expectations of its sponsors, goes after its job like a spirited horse. A steam locomotive, on the other hand, being what might be termed more phlegmatic, and possibly realizing that its best days may be over, will do about so much and no more, and either stalls or loafs over the road without injury to itself. Not so with the electric engine. It may not be subject to "creeping paralysis" but since it leads a strenuous life, it acquires a sort of hardening of the arteries in the way of accumulative depreciation of insulation which leads the way to heavy repairs.

Realization of the extent of accumulation of wear and tear, both electrically and mechanically, makes it difficult to understand just how railroads are to maintain electric locomotives without back shops unless they job the work out to manufacturers of electrical equipment.

Regarding the design of the machinery of a steam locomotive being utterly circumscribed by the necessity for tying it up to a steam boiler, the statement can be made that some modern high powered electric locomotives are so compact with apparatus, both inside the cabs and beneath, as well as on top, that additions to or enlargements of details, even of a minor nature, are well nigh impossible. Furthermore, this is not peculiar to ac-dc machines.

When one comes to attempting the solution of the problems attendant on the heating of passenger trains, electrically drawn; to find room for the boiler, water and fuel oil storage auxiliaries, etc., and keep within weight limitations, the difficulties are very real and certainly lead one to the conclusion that on electric passenger power the boiler is circumscribed by electrical apparatus.

In surveying electrification broadly, one finds there is a vast field of opinion among electrical engineers as to types of installations. Is it possible that by so many widely divergent electrical means the final net results are always to the discredit of steam operation? Can any type of electrical layout beat steam? Even if so, it is hardly probable that each electrical arrangement can be as good as every other one.

It appears that when a railroad goes in for electrification, it must settle on some type of lay-out, the main characteristics of which are fixed. Extension must either be along the original plan as to power characteristics, distribution or collector apparatus, or else vast sums must be spent to re-vamp the existing plant if the new lay-out is not to be largely separate and independent with all of the inherent disadvantages of non-interchangeability and those arising from the lack of flexibility.

The steam locomotive, except in a moderate way as to clearances and weight limits, has a wide range of application. Railroads loan steam power back and forth with advantage usually to both parties, but no case comes to mind where electrical equipment for heavy traction can be interchanged.

The design and operating characteristics of steam power have developed far more along lines of possible common usage and practice. It is to be hoped that the lines of development of electrical facilities will tend to converge rather than diverge too widely.

Some reasons for such desirability are:

(a) Railroad Managements will not be so fearful of becoming tied up with a heavy and inflexible type of investment, which may quickly become obsolete through not lending itself reasonably well to extension or modernization.

(b) The need for a broader field of design and manufacture of equipment and the furnishing of repair parts for the same.

Dependence largely on one manufacturing concern which must unload heavy overhead charges at surcharge rates, unheard of in the case of steam locomotives, is highly undesirable and is restrictive to the extension of electrification.

Study and comparison of the details, item for item, of any large activity, is necessary in order to get the benefit of real analysis, but satisfactory conclusions as to the merits of the entire project cannot be reached by setting up in a partisan way outstanding advantages on the one hand any more than by listing all the disadvantages on the other.

Certain more or less intangibles are important and must be weighed impartially. Among such are the increase in real estate value through electrification, increased capacity of road, comparative safety and reliability of operation, permanence of type of design, obsolescence and depreciation factors, etc.

Tangibles from a money standpoint can and should be segregated and set up in full scope on both sides of the case and conclusions based on the net result at the bottom line of the balance sheet. If fixed charges on plant, including equipment, plus maintenance charges, plus other out-go, outweigh the savings in fuel, plus other operating savings, the net result is a deficit and all manner of proclaiming isolated pecuniary advantages would not induce a careful investor to support the enterprise.

Possibilities of Electrification Should Be Investigated Thoroughly

George Gibbs, chief engineer electric traction, Long Island, stated that, as regards simplicity, the self-contained steam locomotive has an inherent advantage over the combination of elements required for electric propulsion, and the latter must show some peculiar advantages in an operating, rather than a structural sense, if it is to supersede steam traction. Due to the large investment in steam locomotive equipment, he said that in any event steam motive power can be displaced only by slow degrees and railway men can discuss the new rival with calmness. After presenting a general picture of the situation, Mr. Gibbs concluded by saying that the available facts indicate the utmost importance of carefully and painstakingly investigating each proposed application to insure that it is properly conceived and carried out.

Carefully Correlated Data Is Needed

The discussion prepared and submitted by E. B. Katte, chief engineer electric traction (N. Y. C.), expressed the opinion that too much has been claimed for the steam locomotive as well as for the locomotive operated by electricity. Without doubt, he said, there are advantages peculiar to each, but it will always rest with the railroad engineer to determine and decide which type of locomotive will be best suited to the peculiar conditions surrounding the railroad which he serves. He produced a table which showed that fuel consumption data is apt to be misleading in so far as comparisons are concerned, due to widely different conditions on the various roads in question. He concluded his remarks as follows: "Finally, too much reliance should not be placed on results obtained from test runs, even if they fairly well simulate actual conditions. To be of comparative value, service records should extend over several years, and the data should be carefully collected, correlated and averaged to give results that may be expected in every-day operation."

Recent Activities of the American Welding Society

The American Welding Society called a special meeting of its New York members on October 14, at the Engineering Societies Building, for the purpose of forming a Metropolitan Section of the society. This movement is in line with the practices that have been adopted by the large national engineering societies and already sections have been organized in Philadelphia, Chicago, Cleveland and Pittsburgh. It is expected that other sections will be organized as rapidly as the membership in any particular locality warrants such organization.

The tremendous interest evidenced in the subject of arc welding is clearly shown by the fact that the welding art, or applications of it to the industries of this country, has grown and multiplied more in the past three years than would ordinarily have taken place in ten years. This interest throughout the country has no doubt been developed very largely through the activities of the welding society. The membership has doubled in the past six months and there is no question but what the organization is on the upward shoot and no reason whatever why the membership should not again be doubled in the next six months.

The older engineering societies started out as national societies without any idea of sections, but as the interest of more distant groups became of importance it became necessary to establish sections. In most cases there was no New York section until several of the other places had formed theirs, for the reason that New York had been the headquarters of the original national body. All of these older societies have now, however, started New York sections and there was no reason why the welding society should not establish one also.

About forty members were present at this meeting. A nominating committee was appointed by Comfort

A. Adams, who acted as chairman of the meeting. He also appointed a committee on constitution and by-laws. In order to make the local organization a going affair from the start, 125 members of the parent organization, residing in New York and vicinity, automatically become members of the local section and a corresponding proportion of the dues, which have been paid into the parent organization, will be turned over to the local organization.

The nominating committee of the newly formed Metropolitan section held its first meeting on the afternoon of October 25, in the Engineering Societies building, at which time the following list of nominations was drawn up.

Chairman	H. A. Currie, Assistant Electrical Engineer, New York Central Railroad.
1st Vice-Chairman	E. E. La Schaum, General Superintendent Motor Equipment American Railway Express Company.
2d Vice-Chairman	E. M. T. Rider, Chief Engineer, Third Avenue Railway Company.
Treasurer	W. E. Gray, Jr., New York Sales Manager, Elyria Enameled Products Company.
Secretary	Howard Odiorne, Submarine Boat Corporation.

EXECUTIVE COMMITTEE

To serve for three years:	
H. G. Thompson	Transportation Engineering Corporation.
William R. Hulbert	Metal & Thermit Corporation.
E. J. Kingsbury	United Marine Contracting Corporation.
J. C. O'Connell	Federal Shipbuilding Company.
To serve for two years:	
F. W. Smith	Chief Engineer, Oxweld Acetylene Company.
A. E. Gaynor	J. A. Roebling's Sons Company.
Charles H. Haupt	Standard Oil Company.
Charles P. Burr	G. M. Meurer Steel Barrel Company.
To serve for one year:	
R. W. Baker	Lincoln Electric Company.
D. Ahldin	Commercial Acetylene Supply Company.
M. W. Kellogg	M. W. Kellogg Company.
Allen L. Price	Beckley Perforated Company.

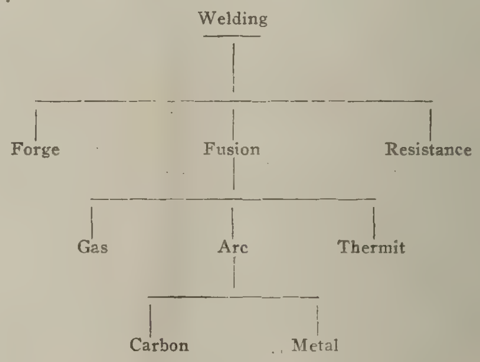
The National Body Meets

The American Welding Society held a meeting on October 25, at 8 p. m., at the Engineering Societies building, the object of which was three-fold. The first matter for consideration was the ratification of the by-laws of the society as amended by its Board of Directors, second, the announcement of the organization of the Metropolitan section of the society, and, third, the presentation of a paper, entitled, "The Arc Welded Battle Towing Target No. 60," by Commander H. C. Knox, U. S. N., and James W. Owens, welding aid at U. S. Navy Yard, Portsmouth, Va.

Very shortly after taking up the matter of the ratifications of the by-laws as amended by the Board of Directors, it became apparent that there was considerable opposition to these amendments by certain sections of the parent body. In order that too much of the evening should not be devoted to a discussion of the by-laws and a futile attempt made to reconcile them to the various sections of the organization, Comfort A. Adams suggested that the Board of Directors confer with the several sectional bodies with the idea in view of modifying the amendments to such an extent that they would be satisfactory to all concerned. This suggestion was put in the form of a motion and it was voted to withhold the reading of the proposed amendments until some future meeting of the society.

Prior to his describing the welding of the battle towing target, Mr. Owens made a number of remarks relative to the field of welding. On looking into the future he said he could foresee a time when large city structures would be welded, also when ships would be welded, but before that time arrives it is going to be necessary to very largely increase the number of welding engineers. In order to meet this demand in the future for welding engineers, he offered as a suggestion that the colleges and universities of the country should place upon their curricula post graduate courses in this subject. Mr. Owens emphasized the fact that the need for trained welding engineers was growing more urgent every day. The ability to determine whether a certain piece of welding should be done by the thermit method, by the arc welding method or by the gas welded method, is the paramount necessity for successful welding, and the lack of this ability has doubtless been no small obstacle in the solution of welding problems. In every case the kind of weld depends upon the kind of job.

In order to present more clearly to the members the various divisions and sub-divisions of the welding art, Mr. Owens drew upon the blackboard the following diagram:



The description of the arc welded battle towing target, the paper of the evening, was well illustrated with numerous lantern slides which clearly showed the various steps of its construction from the very beginning to the final launching of the target. Mr. Owens stated that the object of welding this target was to find out how practical this kind of welding would be when applied to this type of construction. Until recently such welding has been confined to minor parts of ships. One of the points emphasized was the fact that a butt welded joint is unsatisfactory unless reinforced. A single beveled T-joint is likewise unsatisfactory, it being much better to use a square T-joint with a filet above and below.

With reference to the saving that might be effected on a large welding job of this kind it was estimated that $4,500 can be saved on such a target if constructed with a properly trained organization at whose head is placed a thoroughly trained welding engineer. The conclusions to be gathered from the results obtained on the battle towing target are such that it may be said that arc welding can be very satisfactorily used in ship construction provided the work is done by properly trained men and the joints are properly designed. Inspection must be made while the work is being done instead of being made after the work is finished. A welder on ship construction must be able to perform his work in any possible position, and with the best type of man available there is no longer any question but that the satisfactory welding of ships can be an accomplished fact.

Principles of Car Lighting by Electricity

A Course of Practical Lessons Explaining the Main Details of This Important Application

By Chas. W. T. Stuart

IV. Regulating Apparatus for Axle Generator Systems

THERE are two regulators in common use with each axle generator system—a dynamo regulator and a lamp regulator. There are some systems that require no lamp regulation, but the majority of systems use both lamp and dynamo regulators. It would be rather confusing if an attempt were to combine every minute detail of the many types of regulators with the various car lighting equipments. The set of regulators used in this lesson will cover the general principles involved in the majority of car lighting regulators. In later lessons we will study each equipment individually.

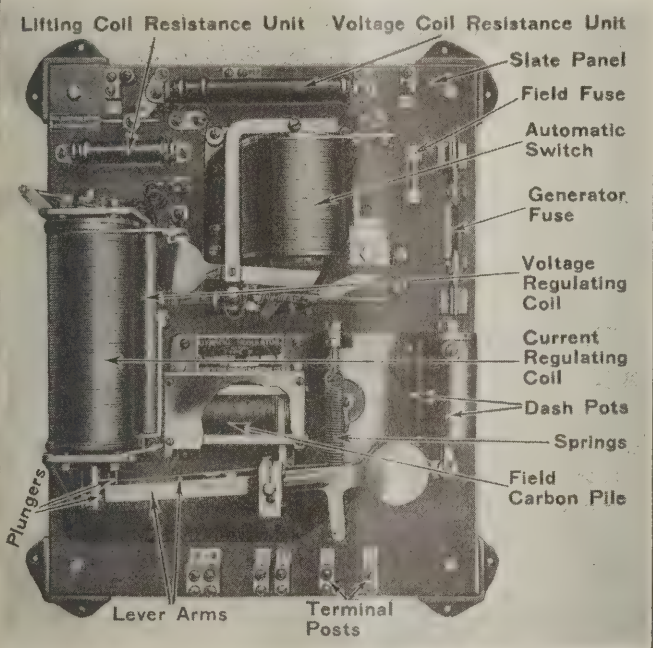


Fig. 1—One Type of Dynamo Regulator Panel

Dynamo Regulator

The dynamo regulator, frequently known as the generator regulator, connects the generator to the car wiring, controls the generator voltage and current and the rate of battery charge. There are two methods of current regulation—the total current regulation and battery charge regulation.

Total Current Regulation

If the generator regulator controls the total generator current it is said to be connected for total current regulation—meaning that the generator output is constant, regardless of the lamp load. For example, if the generator output were 65 amperes and the lamp load were 15 amperes, the battery would receive the difference, or 50 amperes, and when the lights were off, the battery would receive the total 65 amperes. Of course, the regulating and field coils take a few amperes, but this can be neglected at present for simplicity.

Battery Charge Regulation

If the generator regulator controls the rate of battery charge, it is said to be connected for battery charge regulation and its total generator output will be the sum of the battery charging current and the lamp load or an increase of output as the lights are turned on. For example, if the battery current were regulated at 45 amperes and the lights off, the total generator output would be 45 amperes, and if the lights were switched on, adding a 15 ampere load, the total generator output would be 45 plus 15 or 60 amperes, neglecting the small regulating and field current as above.

Dynamo Regulator Parts

The dynamo regulator that we will study will be connected for total current regulation and consists of the following—a slate panel (upon which is mounted an automatic switch), field carbon pile, voltage regulating coil, current regulating coil, field and generator fuses, and the necessary dash pots, plungers, lever arms, resistance units and the terminal posts, as shown in Fig. 1.

The function of the slate panel is to carry the various regulating parts. Slate is a non-conductor and therefore is well suited for this purpose.

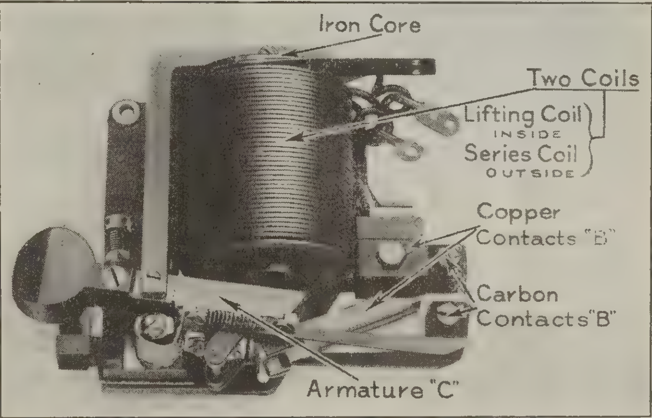


Fig. 2—Enlarged View of an Automatic Switch

The automatic switch, Fig. 2, connects the generator to the car wires and to the battery. This switch consists of two coils (a lifting coil and a series coil), an iron core, a movable iron armature, and two sets of contacts (copper and carbon). The *lifting coil* is connected at all times across the generator brushes and closes the switch when the generator voltage is slightly in excess of the normal battery voltage. The *series coil* holds the switch after it has been closed by the lifting coil and also opens the switch when the generator voltage falls below the battery voltage.

The operation of the automatic switch is as follows: With no current flowing, the armature, Fig. 2, will be held down by its own weight and the main switch contacts will be open. As the generator voltage builds up, current flows through the lifting coil. When the generator voltage is slightly in excess of the battery voltage the lifting coil produces a magnetic flux in the iron core strong enough to raise the armature and close the main switch contacts *B*. The closing of the switch sends the generator current through the series winding of the automatic switch. The magnetic pull of the series coil is now added to that of the lifting coil and the switch is held firmly in a closed position. When the generator voltage falls below the battery voltage the current flows through the series winding of the automatic switch in the opposite direction. When the current is flowing in this direction, the magnetic effect of the series coil opposes the magnetic effect of the lifting coil, and when they neutralize each other, there being no magnetic pull on the armature *C*, the pull of gravity forces the armature downward and opens the main switch contacts. The *copper contacts* are the main conductors. The *carbon contacts* protect the copper contacts by taking the arc when the switch is opened.

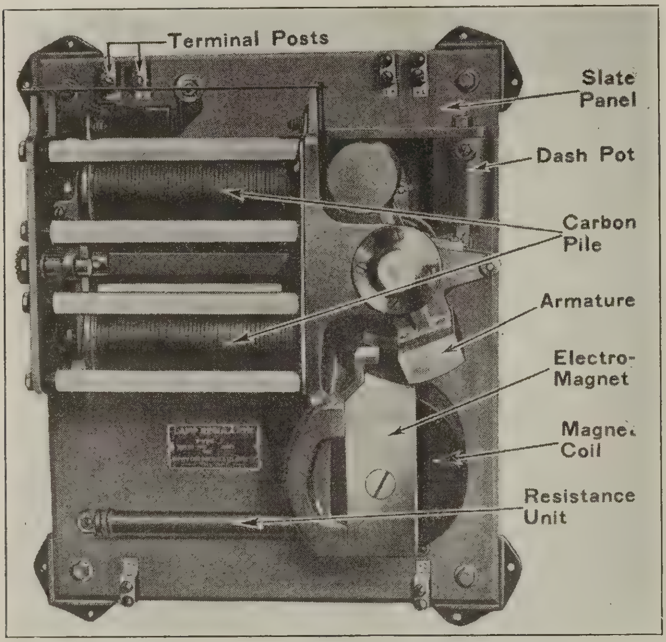


Fig. 3—One Type of Lamp Regulator Panel

The *field carbon pile* is made up of a number of thin carbon discs and is connected in series with the field circuit, thus controlling the generator excitation. The resistance of this field carbon pile is varied by the movement of the plungers of the voltage and current regulating coils.

The *voltage regulating coil* is connected at all times across the generator brushes and controls the voltage of the generator by varying the resistance of the carbon pile. The coil controls the plunger whose arm acts directly on the carbon pile. The magnetic pull of the coil on the plunger is opposed by a spiral spring, Fig. 1. The spring is adjusted so that it will balance the magnetic pull of the coil on the plunger when the generator voltage is normal. For example, with no current passing through the coil, the plunger is pulled to its extreme downward position, compressing the field carbon pile. This condition remains while the generator voltage is normal or below normal. Should the generator voltage rise above normal, the magnetic pull of the coil will overbalance the pull of the spring and move the plunger upward. The plunger moving upward raises the arm and releases the pressure on the field carbon pile. This increases the resistance of the field carbon pile, thereby lowering the generator field current. This, in turn, reduces the generator voltage, and when the generator voltage reaches its normal value, the magnetic pull of the coil and the pull of the spring are equal, and the plunger is held in balance.

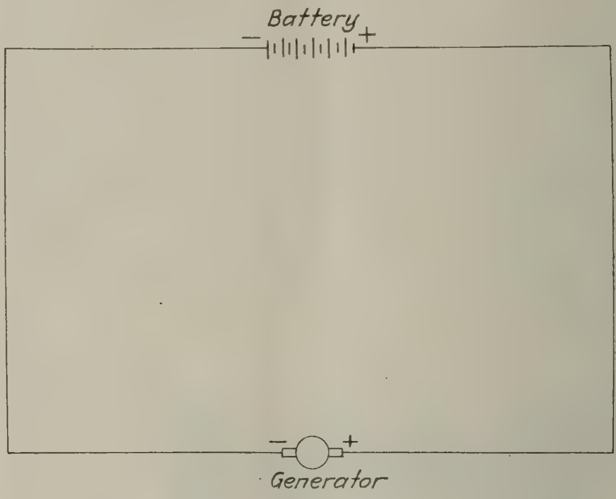


Fig. 4—Main Generator and Battery Circuit

The *current regulating coil,* Fig. 1, is connected in series with the main generator circuit and controls the generator current by varying the resistance of the field carbon pile. The current coil controls the plunger whose arm acts on the carbon pile. The magnetic pull of the coil on the plunger is opposed by a spiral spring. The spring is adjusted so that it will balance the magnetic pull of the coil on the plunger when the generator current is normal. For example, with no current passing

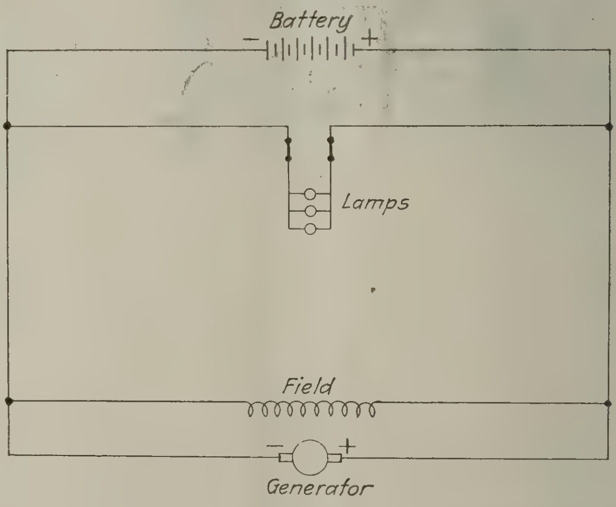


Fig. 5—Field and Lamp Circuit are Connected Across Generator and Battery Circuit

through the coil, the plunger is pulled to its extreme down position by the spring and the field carbon pile is fully compressed. When the current begins to flow through the current coil, the spring holds the plunger in its extreme down position until the current rises above its normal value. Then the magnetic pull of the coil will overbalance the pull of the spring and move the plunger upward. The plunger, in moving upward, raises the arm and releases the pressure on the field carbon pile. This increases the resistance of the field carbon pile, thereby lowering the generator field current, which in turn reduces the generator current. When the generator current reaches its normal value, the magnetic pull of the coil and the pull of the spring are equal and the plunger is held in balance.

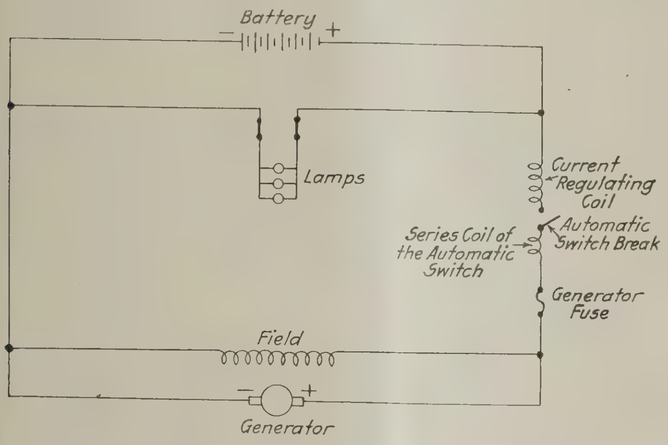


Fig. 6—The Generator Fuse, Series Coil, Switch and Current Regulating Coil are Connected in Series in the Main Circuit

Air *dash pots,* Fig. 1, are used to dampen the movement of the plungers and lever arms. The dash pot consists of a brass shell with a graphite plunger. A small hole is drilled in the side of the shell to permit the air to escape.

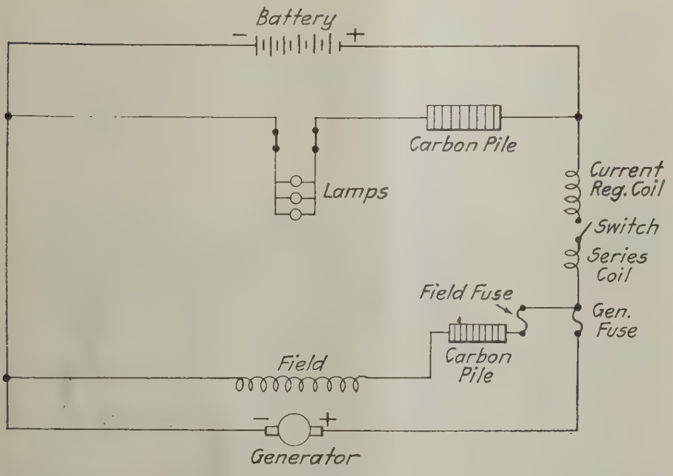


Fig. 7—The Field Fuse and Carbon Pile Connected in the Field Circuit—the Lamp Carbon Pile Connected in the Lamp Circuit

Resistance units, Fig. 1, are connected in series with the lifting coil of the automatic switch and the voltage regulating coil. The resistance unit that is connected in series with the voltage coil is provided with a number of taps for shunting out sections of the unit. This provides a means of adjusting the generator voltage setting. Some regulators have a field exciter unit, but we will exclude that in this lesson to avoid confusion.

Fuses.—Most regulators are equipped with two fuses. One, a small fuse, is connected in the field circuit, and the other, a much larger fuse, is connected in the main generator circuit. The function of these fuses is to protect the armature and field circuits.

Terminal posts are located on the regulator panel to serve as a means of connecting the wires to the regulator.

Lamp Regulator

The lamp regulator, Fig. 3, holds the lamp voltage constant when the generator or battery voltage rises above the normal rated voltage of the lamps. It consists of a slate panel upon which is mounted a carbon pile, an electro-magnet, a resistance unit and the necessary levers, dash pot, and terminal posts, as shown in Fig. 3.

The *lamp carbon pile* is made up of a number of carbon discs and is connected in series with the lamp circuits.

The *electro-magnet* consists of a coil with its core and armature. The coil is connected across the lamp mains, and operates on the carbon pile as follows: With the lights off, no current flows through the magnet coil and a spring holds the carbon pile compressed. When the lights are switched on, the current to the lamps flows through the carbon pile. Current will also flow through the magnet coil. If the lamp voltage is above normal, the magnet becomes stronger and pulls the armature down, opposite the pull of the spring, and reduces the pressure upon the carbons. This increases the resistance of the carbon pile, and reduces the lamp voltage to normal. When the normal lamp voltage is reached, the pull of the magnet and the spring will balance and the armature will remain in that position until there is another change in the lamp voltage.

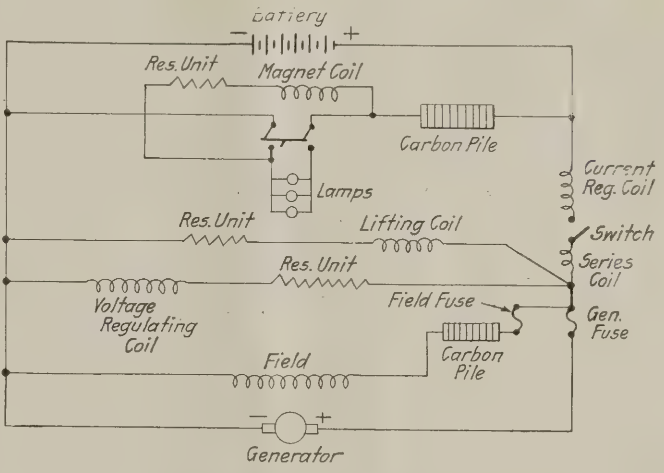


Fig. 8—Lifting Coil, Voltage Coil and Lamp Magnet Coil Circuits Added

The *resistance unit* is connected in series with the magnet coil. The *dash pot* is the air type and dampens the movement of the armature and levers. It is constructed the same as those described with the dynamo regulator.

Wiring Diagram

With the knowledge of the wiring of the straight storage system and the axle generators which were given in previous lessons, added to the description of the regulators given in this lesson, we should be able to study the wiring of an axle generator system with ease. However, to get a general idea of the various connections and paths of the electric current, suppose we study them by taking a sheet of paper and a pencil and drawing a simple wiring diagram step by step as follows: First, draw the main circuit connecting the positive side of the generator to the positive side of the battery, and the negative side of the generator to the negative side of the battery, as shown in Fig. 4. Second, connect the field and lamp circuit across the main circuit, as shown in Fig. 5. Third, connect the generator fuse, automatic switch series coil, automatic switch break and the current regulating coil in series with the main circuit, as shown in Fig. 6. Fourth, connect the carbon pile and fuse in the field circuit, as shown in Fig. 7. Note that the positive side of the field circuit runs to the regulator panel, where it takes in the carbon pile and field fuse and is then connected to the positive side of the generator. Also connect the lamp carbon pile in the lamp circuit, as shown in Fig. 7. Fifth, complete the wiring diagram by connecting the three shunt circuits. These shunt circuits are—the lifting coil circuit, the voltage coil circuit, and the lamp magnet coil circuit. The lifting coil is connected across the main generator circuit in series with a resistance unit, as shown in Fig. 8. The voltage regulating coil is connected across the main generator circuit in series with a resistance unit and is also shown in Fig. 8. Note that both the lifting coil and the voltage coil circuits are connected on the generator side of the automatic switch. The lamp magnet coil is connected across the lamp mains in series with a resistance unit, as shown in Fig. 8. Note that the magnet coil circuit is controlled by the light switch, as one side of the circuit is connected to the load side of the switch. When the lights are turned off no current will flow in the magnet coil.

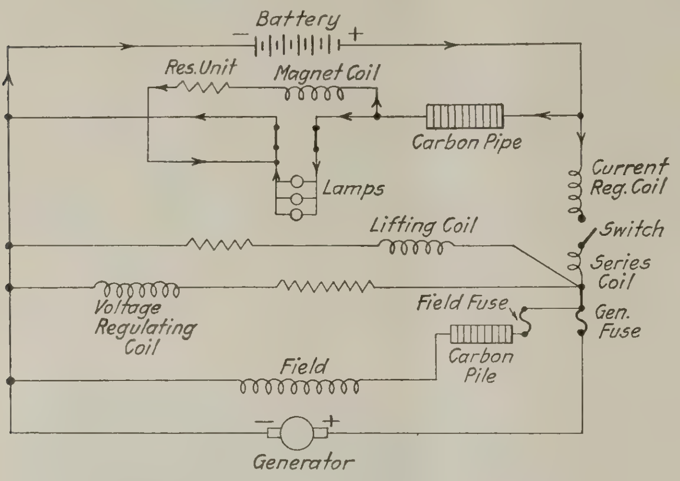


Fig. 9—Arrows Indicate Flow of Current from Battery to Lamp and Magnet Circuits—Car Standing and Automatic Switch Open

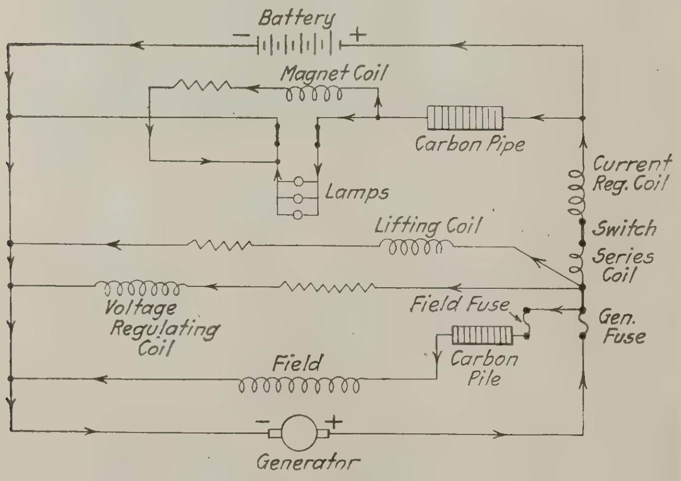


Fig. 10—Generator Operating at Full Load—Current Will Flow Through the Various Circuits as Indicated By Arrows

Flow of Current

The arrows in Fig. 9 show the path of the current through the lamp and lamp regulator magnet coil circuits when the car is standing and the generator not operating. Trace the lamp current from the positive side of the battery to the lamps and back to the negative side of the battery. The current to the lamp regulator magnet coil flows from the positive side of the lamp circuit through the magnet coil and its resistance unit back to the negative side of the lampcircuit. Fig. 10 shows the flow of current with the lights on and the generator operating at full load. By following the arrows in Fig. 10, you can trace the generator current through the various circuits.

A Correction

In the last installment of this series which appeared in the September issue an error has been discovered which we are desirous of correcting. The mistake occurs in Fig. 10 on page 314. In this illustration the positive brushes should have been located at points 1 and 3, and the negative brushes at points 2 and 4.

• • • •

Copyright by Ewing Galloway, N. Y.

A Train of Loaded Tank Cars, Nearly Half a Mile Long, from Sinclair Oil Refinery at East Chicago, Ill.

Railway Electrical Engineers Meet At Chicago

Abstracts from the Discussion of the Various Reports Presented at the Recent Convention

THE twelfth annual convention of the Association of Railway Electrical Engineers was held at the Auditorium Hotel, Chicago, October 18 to 22, inclusive. The first business session was called to order Tuesday morning, October 19, at ten o'clock by the president, L. S. Billau.

In his opening address Mr. Billau extended a hearty welcome to the members of the association and stated that it was a pleasure to note the increasing interest in the activities of the organization as evidenced by the large and representative attendance of members. In part, Mr. Billau's remarks were as follows: "We are all aware of the increasing importance of the various established railroad associations in the operation of the railroads of this country. One of the lessons of the war conditions is the need for better and closer co-operation. Standardization of practices on many details of equipment can, with advantage, be largely extended.

"New and serious problems are facing the railroads today in which electricity, in one or more of its many adaptations, will play a large and important part. To meet these new duties and increased responsibilities this association must expand and develop. As a step in this direction consideration is being given to the amalgamation with one of the sections of the American Railroad Association. In the meantime, certain amendments to the constitution of this association have been considered, the adoption of which it is felt will be of material benefit.

"The real work of the association is done by its committees and our accomplishments are largely measured by the reports that are presented. It, therefore, becomes of increasing importance that the subjects investigated are handled broadly, yet thoroughly, that the reports are constructive in character and that the recommendations made represent careful and mature thought, reflecting not so much the ideas of the individual railroads, but the best practices considering the railroads as a whole.

"One of the advantages of this association is the opportunity for thorough discussion of the committee reports on the floor of the convention. These discussions are valuable to the extent that they are constructive, stick to the subject and avoid non-essential details. I am in favor of active discussion of the reports as the views of the various railroad men and others who speak are of value not only to those who are present, but are permanent records that are of assistance to succeeding committees. If these suggestions will be kept in mind there will be ample time for a full discussion of the reports and still keep within the schedule set by the program.

"The exhibits form an important part of our convention. Our program has been arranged to set aside the afternoons for inspection and study of the exhibits. I, therefore, recommend to the members and visitors not to scan over them casually, but to take the time to study them thoroughly. On the other hand, I suggest that during the morning session hours that all of us devote our entire time to the meetings, in which connection I invite the representatives of manufacturers to co-operate with us by attending the meetings, particularly those in which they are directly interested.

"In closing my hope is that this convention will be as successful and as beneficial to all as have those in the past and that as we go on from year to year in whatever form our organization may assume, we will continue to expand and render more and more service to our railroads."

Immediately following the opening address of the president the report of the secretary-treasurer was presented, followed by the report of the Auditing Committee.

Under the subject of unfinished business one matter came up for consideration—the question of amalgamation with the American Railroad Association. At last year's convention the executive committee of the association was authorized to enter into negotiations with the American Railroad Association on this matter. On account of various conditions that have developed during the year it has been impossible to present any definite report at this time. The executive committee has the matter under consideration, however, and as soon as it is possible to reach a point of negotiation where something can be stated definitely it will be brought before the members of this association.

Under the heading of new business the question of adopting a number of new amendments to the constitution was taken up. These amendments, which were published on page 316 of the *Railway Electrical Engineer* for September, were read by Mr. Billau and were adopted individually by the association.

Immediately following the adoption of the amendments the report of the Committee on Illumination was presented, abstracts from the discussion of which are as follows:

Discussion of Report on Illumination

THE PRESIDENT: Since the topic was first brought to our attention we have found six types of lamp bulbs used in train lighting, such as the S-F 17, 19, T. F. 20 and T. F. 25 T., taking nine reflectors. There are 15 different positions for mounting the lights and you can readily appreciate the difficulties you will encounter when you switch from one type of bulb to another. I think all will agree that it is a move in a right direction and one that possibly should have been taken years ago in attempting to standardize lamp position with respect to reflectors for train lighting service. This subject, while it was not originally referred to the committee to investigate, seems to be of sufficient importance for the committee to take up and for the association to act upon. I have been assured by some of the leading reflector manufacturers and fixture manufacturers, with whom the committee has been in touch, that they will be guided in the future by whatever action is taken by the association. In view of the fact that the committee's report covers several distinct subjects, I think we will take up each section by itself and dispose of that before going to the next.

F. G. HIBBEN (Westinghouse Electric & Mfg. Co.): I would like to ask if this 50-watt T. S. 20 bulb lamp is the clear bulb or opal glass.

THE PRESIDENT: Clear.

MR. HIBBEN: I have no comments to make from the standpoint of the lamp manufacturers other than we think the substitution of the 50-watt gas filled for the 50-watt vacuum or Type C lamp is a very desirable step.

THE PRESIDENT: I have been given to understand by one of the lamp manufacturers that the proposed new train lighting schedule will include lamps as shown in this report; that is, the standard schedule will include such sizes as 30 to 34 volt range, both mazda B and mazda C lamps, and that certain other sizes, including all the 60 to 65 volt range, would be placed in the intermediate schedule.

A. L. BROE (Edison Lamp Works): The 50-watt and 75-watt mazda C lamps will be included in the standard schedules the next time they are issued.

C. W. BEBOUT (C. & O.): Mr. President, I would like to say unless the manufacturers improve the construction of the Type C lamp it is not going to be very popular with the railroads. I have tried out several makes and the life of them is not very satisfactory.

THE PRESIDENT: The information that has been brought to me is that while the 50-watt mazda C lamp, train lighting size, is a relatively new lamp, it does not involve any radical changes in design. They are using the mazda C lamps in locomotive headlight service in small sizes and undoubtedly when the lamp gets into larger production the manufacture will be improved. I have been given to understand that we can obtain a satisfactory product.

MR. BROE: Mr. Chairman, relative to the question of the strength of the mazda C lamp which has just been brought out, I would say that we have been investigating that and have materially improved the strength of that lamp.

THE PRESIDENT: The cab lamp, I believe, was disposed of at Atlantic City meeting as far as the change in voltage was concerned, so there is no need of discussion on that at this time. We will pass on to the subject of the illumination tests. Has anyone any comments to offer or questions to ask in respect to those tests? If not, we can then take up the last part of the report where the association is asked to make a definite recommendation and that is on the question of standard lamp position.

MR. HIBBEN: I just want to insist on the users of lamps and reflectors making their tests of the relative position of the lamps *with respect to the reflectors*, because when you stop to think about it, the efficiency of the illumination in a car may be practically doubled sometimes by a change of only a half or three-quarters in an inch in the position of the filament with respect to the reflector.

THE PRESIDENT: The committee had those very features in mind when the subject was taken up with the reflector manufacturers. They were only too glad to see some steps taken toward standardization; and while it was not possible to cover all manufacturers of reflectors in the country, it was taken up with those companies who manufacture types of reflectors where accuracy of lamp position is essential for proper distribution. If there is no further discussion on this subject the chair will entertain a motion with reference to this fourth section of standard lamp position covering the last feature on which your committee recommends the association take definite action with reference to these lamp positions at this meeting, in order that the matter may be formally referred to the manufacturers.

J. L. MINICK (Penn. lines): Mr. Chairman, I move that this association recommend to the reflector and lamp manufacturers that lamps and reflectors be so designed that the distance from the top edge of the reflector to the contact point of the base of the lamp can be made 1½ in., 1 in., ½ in. or zero, depending upon the size of the lamps used.

Mr. Minick's motion was seconded by J. E. Gardner (C. B. & Q.) and the motion carried. The report was accepted and the committee continued. This being the only report for the Tuesday morning session, the meeting was adjourned until the following morning.

Discussion of Electric Welding Report

The first committee report presented at the Wednesday morning session was that of the Committee on Electric Welding, of which E. Wanamaker, electrical engineer of the Chicago, Rock Island & Pacific, is the chairman. Mr. Wanamaker abstracted his report in substance, the full report appearing in the October issue of the *Railway Electrical Engineer*. Upon the conclusion of Mr. Wanamaker's summary of the report, the president opened the subject for discussion.

H. C. MELOY (N. Y. C.): Mr. President, I would like to ask Mr. Wanamaker if in his investigation and practices he has found anyone using the arc for wrecking steel cars; that is, cutting out the rivets?

MR. WANAMAKER: We have found if you have a machine available of sufficient capacity and enough of the work to be done, that you can melt off the rivet heads economically. Unless, however, you can keep the machine busy, it would not pay.

E. H. HAGENSICH (U. P.): I would like to ask Mr. Wanamaker if, in his opinion, the portable machine is preferable to the centralized unit, or where you differentiate between the use of the two?

MR. WANAMAKER: Every piece of work is a study in itself; unfortunately, all I can do is to generalize. I might say that on our railroad we have yet to find a place where a multiple unit would prove an economical expense. It depends on the vision, the foresight of the people who are doing the work, as to how far you are going to extend the use of your electric welding and whether you are going to confine the use of it to some one class of work or some one point.

E. S. M. MACNAB (Can. Pac.): Mr. President, in talking the matter over with one of the supply men he mentioned to me that he gets orders for various sizes of flexible wire to be used between the welder to the wire holder. I was wondering if there were any specifications or any definite sizes laid down to cover that work. Possibly if there are not, might there be something done along those lines?

THE PRESIDENT: This question has been given a good deal of consideration by the Baltimore & Ohio Railroad with a view of standardizing a cable of suitable construction and size to be universally used, so that it can be carried as a stock wire. I believe it is one of the phases of the welding subject that a committee could go into to advantage.

It was then voted that the report be accepted and the committee continued.

Discussion of Electric Headlight Report

The President: The headlight question is undoubtedly one of the most active from the electrical man's point of view at the present time. Railroads today are practically 100 per cent. equipped with electric headlights, but in many cases, due to the rush of completing the installations in the time limit set by law and the necessity for our doing this under war conditions, it has necessitated using types of construction and methods that practice will indicate will have to be revised. We have in the report the results of two sets of tests, those made at Nela Park, and those made by the Reading railroad. In that connection I should like to have some suggestions brought out at this time as to what action should be taken with reference to standardizing the practice of photometering headlight equipment.

J. L. Minick: Mr. Chairman, I wanted to wait a little while and let somebody else say something first, because I feel more inclined to answer questions than I do to get up here and make a speech. There is a good deal to be said on this matter of electric headlights; we have only scratched the surface so far. I am going to touch only upon two or three subjects that stand out more or less definite in my mind, and I hope that the discussing of this problem will bring out other questions which will enable us to get a very broad, helpful view of this entire problem, because not only this association but several other associations are vitally interested in this matter.

Position of lamp filament with respect to the reflector is one of the biggest factors in the promotion of successful illumination.

Successful welding with the electric arc cannot be accomplished by haphazard methods. Every piece of work is a study in itself and efficient results come as a reward of clear vision and foresight in the proper selection and correct application of the welding equipment.

Headlights can be mounted on top of or in the center of the smokebox. Which place is the better and why?

The chairman of the committee made a statement just a moment ago which I do not entirely agree with, that is, that we may find it possible to use relatively small lamps in shifting service. I am not entirely sure of that. We can get along with low candle power value but if we are going to use metal reflectors, silver plated, the deterioration of the reflectors is so rapid and so extensive that it will be necessary to use lamps and equipment which will give relatively very high initial value. We find that normally in our service it will very likely be necessary to resilver or at least repolish to a high degree each reflector every six months. In order that we may repolish our reflectors not more frequently than once every six months we have to have an initial value—roughly, 100 per cent greater than the minimum working value.

With reference to the mounting of the headlight at the center of the smoke box, it frequently happens that something gets wrong with the smoke screen and the smoke and hot gases are not discharged from the smoke box as they should be. This tends to overheat the front end and in that condition it is quite flexible. From a mechanical standpoint, therefore, locating the headlight in the center of the smoke box is not desirable whereas it might be desirable from an electrical standpoint.

I also want to touch upon the matter of the casing itself. I am not just sure that all of the headlights that we are buying today on the open market are made from so-called rust proof steel, which will stand up in locomotive and car service for a period of 8 or 10 years, and I see no reason why that should not be used. Cast-iron cases, I understand, cannot successfully be made with a thickness of much less than a quarter of an inch. A casing for an 18-in. reflector having a shell that thick is going to be extremely heavy and I cannot see the necessity for it. I may be wrong; I am willing to be convinced.

The Cleveland tests are interesting in several ways. First, I want to refer to a statement that is made in the test. I will just take time to read it to you. It is only one sentence. "An analysis of the curves indicate that under conditions at Nela Park field today. . . ." Right there is the point I want everybody to get. While I do not doubt the accuracy of the work at Cleveland—I do not question the report in any way—I do want to point out that one thing, that is, that this test is good for Cleveland, Ohio—a little more specifically than that—it is good for Nela Park, but it might not be good for the New York Central tracks. The test also suggests that glare is a very objectionable feature of electric headlights, and a point to which some attention can be given with a view of reducing it. I can't see any very easy or very readily obtainable method of eliminating glare at the present time, except possibly in shifting service. The size and shape of the filament winding will have a lot to do with the final results. We find that with lamps made by the three larger manufacturers you can get three different results, even though the lamps are of the same candle power, the same lumen value, the same voltage, etc., due entirely to the fact that the filament windings are different.

The President: I should like to ask Mr. Minick if the Pennsylvania Railroad has been doing considerable experimenting in photometering of headlight reflectors following the methods prescribed in the Master Mechanics' Association report, two or three years ago, as to the detail of procedure.

Mr. Minick: Mr. Chairman, it has been so long since I read over that report that I do not know. I can tell you what we are doing, however. We have spent a little money on developing a table for mounting the headlights,—a table which will permit of rotating the headlight upon its vertical axis as well as its horizontal axis. Incidentally the platform on which the headlight is mounted is capable of being elevated, both longitudinally and laterally, so as to make the final adjustment by shifting the headlight so that the center of the light-giving element is at the intersection of the vertical, horizonal and longitudinal axes of the reflector, itself. Our practice is to take lumenometer readings of the candle power at a distance of 50 ft. from the center of the headlight, that is, the focal center. The only unusual feature about our particular method is the fact that we have constructed a device which makes it relatively easy to mount and handle the headlight during a test period. We have found that it is going to take a minimum of, roughly, 500,000 candle power at the center of the beam to enable you to get the 800 ft. distance required by the Interstate Commerce Commission. The order requires that all of this shall be done on a clear, dark night—and I would like to have you tell me what that is—with observers having normal eyesight and the object down on the track to be a man of normal size dressed in dark clothing. There are quite a number of variables there for which no standards have ever been fixed.

I might say one word further, Mr. Chairman, that there is a movement on foot at the present time among several of us who are interested in this problem, to work out a quick, easy method of photometering or measuring headlights. Just how soon it will be ready I cannot say at this time.

J. R. SLOAN (Penn. Lines): Mr. Chairman, Mr. Minick has just called attention to the looseness and ambiguity of the law. I would like to ask if there is any movement on foot to clarify the wording of the law and put it in engineering language so that any man can know what it is that is wanted.

THE PRESIDENT: Personally, I do not know of any present action being taken.

MR. MINICK: I do not know of any.

G. R. SHIRK (C. & G. W.): In regard to Mr. Minick's remark relative to the front end heating, it is a well known fact that the front end of a locomotive heats to cherry red only when there is a leakage of air through the front end. In the past standards the railroads used the cast iron front end and that cast iron front end was done away with on account of the cracks and leakages of air and a pressed steel front adopted. I do not know that I have seen a front end red hot in twenty years.

MR. MINICK: I do not mean to apply that all this was on the Pennsylvania Railroad, however; I have seen hot front ends both on the Pennsylvania and on a number of other railroads. I do not mean by that either that there is a very high percentage of them, but this is true, that even though the front end is not heated very hot, a pressed steel front end is far more flexible than a cast iron front end, and even though it is relatively cold you are going to have more or less movement of this front end on account of the exhaust of the locomotive.

G. SALMON (Can. Natl.): Mr. Chairman, I think it is very important to remember that each road adopts its own ideas anyway as to the placing of the headlight on the top or on the front end, but as to the reflected rays of light, I think there is very little difference under the tests that I have conducted.

E. W. JANSEN (Ill. Cent.): I would like to ask if anyone has had any experience over a year or more with cast iron headlight cases with glass reflectors compared with sheet steel. I know the Northern Pacific has been using quite a few and they are very well pleased with them. I would like to get some information on that point.

THE PRESIDENT: On this subject of reflectors we all know the present practice is largely to use the silvered metal reflector. The use of the other forms is somewhat in its infancy. We know that the deterioration of the silvered metal reflectors is rather rapid and it would be of interest to bring out the practice of some of the roads as to the methods of resilvering or repolishing.

MR. BEBOUT: We have quite a number of tunnels and we find the steel cases are giving us a lot of trouble. We have not decided to adopt cast iron headlights yet, but we are going to try them out. Only this year I found that we were having some trouble about the headlights not focusing properly, and in going over the road I found that the real trouble was due to the reflector lamp being furnished. The lamp that I am speaking about had just two "V" filaments in it and there was not any position you could put that lamp in which you would not have a shadow at some point ahead of the engine. I have recently received notice from one of the manufacturers that they are going to lacquer the silver plate reflectors. I am satisfied that that is going to run up high in maintenance because the men on the branch lines and around the roundhouses are going to get unusually industrious and rub the whole thing off.

A. M. FRAZEE (D. M. & N.): I would like to ask what is the best method yet found for getting the lamp in a center position on the headlight reflector. We are using at the present time some small gage sticks with a threaded tip on the butt of the stick that is similar to the lamp sockets. We screw that into the lamp socket and then take the measurements from the front of the reflectors for various sizes of lamps, guessing as near as we can when we have found the correct position. We have also done some testing by actual trial of the locomotive out on the road. I do not know what method has been found the best.

THE PRESIDENT: Are there some suggestions from the members as to the practices they have found for focusing?

MR. SHIRK: Mr. Chairman, on the Chicago & Great Western each engineer focuses his own light. I guess that is what they do on all the roads.

MR. MINICK: I am not entirely sure that all of the trouble in focusing the lamp is due entirely to the lamp. During the war we all followed the lead of the government locomotives to some extent, which were required to be fitted with headlights made from copper weighing before it was spun to shape, approximately 32 oz. per sq. ft. That copper, to my mind, is entirely too light to be used in electric headlight service. There is excessive vibration on the front end of a locomotive and the 32-oz. reflectors are so light that they can be easily distorted. In regard to the matter of lacquer I am strongly of the opinion that the use of lacquer will put off the evil day of repolishing or resilvering approximately 100 per cent.

Furthermore, if the lacquer is properly mixed and properly applied, I do not think it will flake off. It can be washed with soap and water. The reflector can be washed out with a wet rag without damaging results.

In the matter of focusing headlights in service, we have found that probably the best results can be obtained if a screen is made up in the form of a square frame covered with canvas or cloth of some kind and painted black, then with vertical and horizontal cross lines, possibly 2 in. wide, painted white, with a 2-ft. circle about in the center. If that is set up approximately 15 ft. in front of the headlight and the beam of the lamp concentrated by the direction of the lamp in the reflector so that the entire beam lies within and just touching the 2-ft. circle, you then have your headlight in about the best position that you can get it for road service.

The President: There is another large field for discussion of the headlight situation on the general subject of accessories covering classification lamps and marker lamps as well as various fittings.

ON a clear, dark night, observers with normal eyesight may be able to see a man dressed in dark clothing and—they may not. At any rate the Interstate Commerce Commission's ruling contains too many variables and it should be changed.

The focal point of a headlight reflector is determined quickly and with exactness by the aid of sunlight and a stick.

Engine numbers must be illuminated at night and they must be where they can be easily read.

Mr. Wanamaker: As long as six years ago we hoped that somebody would bring out a superior reflector to the silver plated polished copper. If you are going to use a mirrored glass reflector you must of necessity have a strong headlight case to support it. Therefore, we are trying some now with a cast iron case, a good substantial reflector with a focusing device that the engineers can handle easily.

Mr. Bebout: In answer to the question that was asked a while ago, about getting the focal point of the reflector, about the easiest way to do this is to reverse the conditions. Set your reflector so that the strong light will go into the reflector and you can measure from your rule the focal point. As the light strikes in it will come across from the reflector at different points up to one point. You can stick a piece of wood in and it will burn the wood at the point where the lamp should be focused, that is, if you use strong sunlight to do the focusing.

E. S. M. Macnab (Can. Pac.): Mr. President, I think as far as classification, marker and tender lamps are concerned, we should attempt, as far as possible, to get away from flexible, or portable and semi-portable lamps. In other words, we should make the tender lamps and classification lamps permanent and wire them in permanently.

With regard to the cast iron casing, don't you think that there is some possibility that when we go to the glass reflector that we can get away from the 18-in. reflector and make the casing a good deal smaller than the present 18-in.? That would have the effect of lightening it up considerably. Another thing that would be very helpful would be to get the American Railroad Association to adopt a uniform numbering system. It is rather an important factor on a locomotive in single track operation where the crew of the opposing train has to pick up the correct engine number. For that reason, nobody wants to take very much initiative along those lines.

G. B. Colgrove (Ill. Cent.): I wonder if they have ever considered the placing of the number case separate entirely from the headlight case?

Mr. Salmon: In regard to the number light, we have a V-shaped number light, that goes directly underneath the headlight case. This number light is so constructed that it can be readily opened and the numbers can be easily changed.

Mr. Minick: The display of the number of the locomotive is, of course, one of the very prime essentials. This is even much more so on multiple track than it is on single track roads. For instance, a tower where the tower man is probably not more than 10 ft. above the top of the locomotive and you have four trains passing at one time, it is practically impossible for him to see the number panel if it is on the headlight case mounted at the center of the smoke box, so that if the number plate is to be placed on the headlight at all, it is pretty nearly essential that the headlight be mounted on top of the locomotive. Some roads are using separate number cases. I don't see any great objection to it if they want to do it. Some roads have already started to apply their electric classification and marker lights permanently to the locomotive. While it may be essential for the time being to provide a substitute oil lamp, I do not believe that we will have today, right at the beginning of this work, as many failures of the classification and marker light signals if the electric lights are used, as we would have if we used oil. As an electrical man of course I believe in everything electrical, and I personally can't see why an electric light is not just as reliable and just as satisfactory, in fact it is more satisfactory than the oil light, and if we do not substitute the oil light there will be more incentive to make the electric light more nearly perfect.

Mr. Sloan: Mr. Chairman, I would like to add two more questions to this portion of the report where they recommend it to be taken up with the Train Rules Committee. Question H. Where should the headlight be located? Question I. Why should not a separate numeral panel be provided?

The President: Before we leave the headlight subject there is one question referred to which we might discuss for a few minutes pertaining to the turbine equipment. It is the old question of oil versus grease lubrication. I would like to hear comments from some of the railroad men who are using grease.

Mr. Colgrove: Our road has used grease but we were forced to do that on account of the nature of the mounting of the ball bearings. There is no question but that the oil has every advantage over grease where the ball bearing is properly housed. We have had fairly good results with our grease where we have properly maintained a greasing system.

M. Schwarz (C. M. & St. P.): I represent the Milwaukee road and our biggest bone of contention is lubrication. We all know that the oil in some of the generators and turbines is displaced on account of condensation getting in, and in a great many cases the oiling is neglected. There may be a little scum of oil on top of the water and it may look to the maintainer as though it were full of oil, which is not the case. With grease, however, we have to apply a first-class grease cup, which is filled probably once a week and screwed down every other day to furnish a little new lubrication. On some of the machines we have applied the grease by the aid of a force gun. I am strongly in favor of grease as a lubricant. However, we have got to have the grease on the turbine end that will stand the heat. While we have not made any experiments outside of using different kinds of grease, our results have been very satisfactory.

Mr. Jansen: One of the questions asked is what is the average life of a 250-watt lamp? One large system seems to get a little over a month as an average and they think they are doing well. I have always figured about two months, so I would like to hear from someone as to the average service of the large 250-watt lamps and also if anyone has any real data on the life of the 60-watt lamp, such as is used in switching service. As to the number of extra 250-watt lamps carried for renewals, I will say that on our road we do not carry any because we figure they will get into the fireman's light and unless the 250-watt lamp is carried in the supporting spring the lamp life with the extra lamp will not be any longer than the life of the light that is burning.

The report was then accepted and the committee continued for the next year.

Discussion of the Report on Railroad Stationary Power Plants

The President: With the increasing cost of fuel and labor during the past few years, the stationary power plant has become an important factor from the railroad operating point of view as a place where talent must be expended with careful supervision with a view of keeping costs within reasonable limits. Until recently this association has not given very much thought to the stationary power plant but the subject is one that we are gradually going further into. I think the committee is to be congratulated in covering the subject in a very thorough way.

J. R. Sloan: Mr. Chairman, I noticed that while the committee speaks about and gives a chart showing losses due to not having proper steam pipe covering, they have omitted one phase of the subject and that is that any steam pipe covering ought to be painted in order to preserve the cover. I found that it is of very great advantage if different lines of pipe are painted in distinctive colors and the direction of the flow in the pipe is indicated by an arrow.

J. E. Gardner (C. B. & Q.): Mr. Chairman, this is a good report. I wish it could be in the hands of every man who is operating a power plant on any of our roads. The one thing that surprised me when I first got to checking up our plants was the amount of steam we used for making compressed air. There is one thing that our association really ought to go into and that is the loss in compressed air around our shops and the inefficiency of it. In lots of cases the inefficiency can be corrected by the use of electric power tools instead of pneumatic tools. One thing that is apt to come to the electrical engineer is the work of figuring out whether we can afford to buy power or make it. Occasionally the question is asked you, "Can you save one boiler by buying power?" If the steam that your generator unit or your air compressor is using is used for heating in the winter time, you have got to be very careful about suggesting that you may be able to save a boiler, because when the cold weather comes you still will have to use that steam.

Another item I was interested to see brought out was the question of air leaks in our boiler settings. I checked up one stationary boiler that did not show any leaks that would attract your notice at first glance. We went over that setting very carefully and plugged up all of the leaks. We made one 24-hour test first, then another 24-hour test afterwards, and we showed an increase in efficiency of 10 per cent, just by plugging up those cracks. I am in favor of putting plastic cement on stationary boilers, as recommended in the report, and also in favor of covering it with canvas, painting the canvas to make it as near an air tight covering as you can get on those boilers.

L. C. Bowes (C. R. I. & P.): Regarding the efficient and inefficient use of air, it might be well to bear in mind that in a large yard where air is used at remote points of the yard, small electrically driven air compressors will very often be cheaper than the high maintenance of long air lines from the power house. I think this is a point that many railroads will begin to consider in the very near future.

Mr. Macnab: Mr. Chairman, I would like to ask if the question of superheaters in various terminal power plants has been considered or how far the committee has looked into that question?

Mr. Bowes: In answer to the gentleman's question regarding the investigation of the committee on the application of superheaters to stationary boilers, I will say that the committee has not gone into this subject. Now, there is no doubt that superheated steam will do much to reduce condensation, but I believe that in some of the cases reported a large saving is due to the fact that somebody went into a plant and put the plant in nearly 100 per cent shape, and the saving attributed to the superheater was not all due to the superheater. However, I do believe personally that the installation of superheaters in large terminal plants would be well worth considering.

N. W. Rose (D. & I. R.): On the superheating proposition we found we made a saving by using superheated steam, all right; but we had to be very much more careful in the quality of oil used because with superheated steam, unless a great deal of care was taken with oiling, we had trouble due to the sticking of the cylinders. We also had to be careful, due to the fact that the oil would dry up and we would not be able to get proper lubrication.

Mr. Bebout: There is one point that should be looked out for in putting in superheater installation and that is to be sure that you take up with the manufacturer the question of just how much their engines, that you have in your plant, will stand in superheating. I remember a case several years ago where we put in superheat. We had several engines which were not built for superheating, and we started out with 500 deg. F. and 150 lb. pressure. Even with that low temperature we had trouble with some of those engines. No matter how much lubrication was put in them, they would not run right.

There is another thing, however, I would like to ask, if any of the railroads are using in their larger power plants powdered fuel for operating the plant?

Mr. Bowes: In regard to this powdered fuel proposition I would like to call the gentleman's attention to the report that was made by Mr. Anderson in Milwaukee. It is not a railroad but a central station. He went into the investigation of the use of powdered fuel in large stationary boilers and he found a saving, as I remember, of 1½ per cent over stoker fired furnaces. He made his recommendations that powdered fuel would make no saving on anything under 2,400 hp. and then a saving of 1½ per cent. Now that is with skilled labor and conditions such as are usually found around a large central station plant. Therefore, it would seem to me with the conditions that we find around the ordinary railroad power plant powdered fuel would be a good thing to leave alone for a while at least.

> **LEAKAGE of compressed air from pipe lines and pneumatic equipment is one of the biggest wastes that a steam plant is called upon to supply.**
>
> **Superheated steam may not be suited to the engine and its adoption should be carefully considered.**
>
> **Powdered fuel for railroad plants is a good thing to let alone.**
>
> **Heavy electric traction is demanding more and more attention, but it is a hard proposition to get it away from its arch enemy—the high cost of electrifying.**

The report was accepted and the committee continued. The meeting was then adjourned until the following morning.

Discussion of the Report on Heavy Electric Traction

The Thursday morning session of the convention opened with the presentation of the report of the Committee on Heavy Electric Traction. An outline of the report was presented by J. R. Sloan, chairman of the committee, who spoke in part as follows: "The committee appointed to look into the question of heavy electric traction concluded their work, as it is practically a new subject with them, could best be handled by simply presenting for this year a lot of data as to what sections of railroads have been electrified, together with the characteristics of the power plants, transmission lines, sub-stations and locomotives. No data was included on multiple unit cars for the reason that the committee was pretty well loaded up with railroad work and we really could not get the time to work it up. We have with us today Mr. Allen from the General Electric Company and I have asked Mr. Allen if he would not say a few words on the general question of electric traction."

Mr. Allen took the floor and talked for some length on the various phases of heavy electric traction, dwelling particularly upon the subject of automatic sub-stations.

Mr. Sloan: The committee is prone to error and one error has been called to our attention. I received a letter from the Bridgeport Brass Company, manufacturers of phono-electric wire, calling my attention to the fact that the contact wire used on the New York, New Haven & Hartford railroad was not steel, as stated in the report, but was phono-electric wire. I will admit when I first got the information about the New Haven contact wire, I was very much surprised. I thought the source I got the information from was authentic, however, and I put it down as steel. I see now that I was incorrect.

I would like to have Mr. Hershey from the Westinghouse company give us a few words on the subject of electrification. The report in itself is hardly anything that can be discussed very much and we have got to get in other talent.

Q. W. Hershey (Westinghouse Electric & Mfg. Co.): Mr. Chairman and gentlemen, I thank you very much for calling on me. I did not expect, however, to address you. Mr. Allen has spoken to you on the different systems and I do not wish to discuss that problem. I think the problem before the railroads today is the economics of electrification and a determination of whether they want to electrify or not. Electrification is occupying great interest today, not only before the railroads but the traveling people. Everybody is acquainted with the desirable feature of electrification from the standpoint of cleanliness and the ease with which trains are moved so that there is readily a very well founded public demand. The operations of the electrified systems are very rapidly proving their reliability. Some of the records of operating electrically are really astounding.

Mr. Sloan: The question seems to me as regards future electrification to be more a matter of economics than it is of engineering. Ten years ago a road may have figured out the thing and may have decided they would lose money to electrify the road. Today, they might be making money to electrify it. That is simply due to the increased cost of labor and materials, especially coal. The prices to which coal is mounting and the difference in the consumption of coal per ton mile as between electrically operated trains and steam operated train are sufficient to throw the balance from one side to the other.

A. G. Oehler (Railway Electrical Engineer): Mr. President, I would like to call attention to the fact that there are so many associations interested in the subject of electrification that the solicitation of the various roads for duplicate information has become more or less of a nuisance. I would suggest that the Association of Railway Electrical Engineers should prepare to take part in a movement, including all of the interested societies, to do away with unnecessary duplication of work.

THE PRESIDENT: I might say with respect to the point that Mr. Oehler brought up, that we have given some thought to this question of duplication of work, particularly on the subject of electrification, because it is a popular subject and as I have been given to understand there are six or seven committees of various associations today who prepare annual reports on this subject.

MR. OEHLER: As I see it the problem of electrification is essentially a railroad problem. Roughly, I think it might be divided up into financial, engineering and operating problems and when this movement crystallizes this organization must be ready to take up the work that should be accorded to them.

THE PRESIDENT: At this time, of course, it is impossible to say what will be done and through what channels it will be done.

MR. BEBOUT: I would like to know if any of the records that you have gathered show that electric locomotives are used for hump service in classification yards and if so which is the most suitable for the service, direct current or alternating current?

MR. HERSHEY: To answer the question of the gentleman from a manufacturer's standpoint a locomotive can be built to supply any service required for either alternating current or direct current.

MR. WANAMAKER: I would like to say a word, Mr. Chairman. Mr. Oehler, I believe, referred to engineers, operators and financiers and the desire to divide this work a little bit. If we had not had so much division heretofore we would have seen more electrification, in my estimation. I get Mr. Oehler's viewpoint, I am sure, and his idea is very good, but there has been division on the railroads for the last forty years. As Mr. Allen has said, certainly this is a country of transportation. We can't forget that. One of the chief factors in the legal high cost of living, that which is not due to profiteering and there is a whole lot of it which is not, is due to the fact that our costs of transportation have tremendously increased. We find that we must keep our transportation costs down for the good of the country as a whole. The banker knows that. We can't get away from it. The people are going to insist upon it. Electrical engineers have come to a point in their progress where they will have to know more about these conditions. We find today that instead of the antipathy that formerly existed to electrification the railroad people are looking for light and information. They want to know what can be done.

The report was accepted and the committee continued.

Discussion of the Report on Train Lighting

L. S. BILLAU (B. & O.), chairman: I shall not attempt this morning to go into the report in any way in detail. It was presented in its entirety at Atlantic City; and as it has been all published and is a subject that has been under consideration for the past year or so, it will be simply a repetition of the discussions that have been covered before. I will confine such remarks as I have to make, therefore, to a few minor changes that have been made since the Atlantic City meeting.

On page 368 at the bottom of the page I refer to a clause that has been inserted in the proposed specification. This was inadvertently omitted before. It is the one designated as paragraph (n) and refers to mechanical clearance reading "The mechanical clearance in the air gap shall be such that an oval feeler ½ in. wide and 0.05 in. thick can be placed at all points between the armature and the pole changes."

Another revision is on page 369, under paragraph (l) 6; it reads: "In case of open battery circuits the generator has to be able to carry the lamp load and the generator regulator shall automatically prevent the rise in voltage upon the system exceeding 120 per cent of the rated generator voltage."

On page 370, sub-paragraphs 1 and 2, under paragraph (i) have been revised with respect to the drop in regulator resistance. As it now reads it will "* * * not exceed one volt for 25 amperes flowing * * *," while in the second paragraph the value for the amperes at which the voltage measurements shall be taken was left a blank to be filled in.

I take this opportunity to say that this specification, which was presented to the Mechanical Section of the American Railroad Association at the June convention, has been adopted and is now part of the recommended practice of that association.

The question has been raised as to whether or not it would be desirable to provide in the specification operating limits for two types of lamp regulators, one as now covered in the specification and a second type where the limits are a little wider to cover a type of lower priced regulators that many railroads might desire to use on baggage and express cars. The committee went into this subject to some extent and decided to take no action this year but to leave it open as one of the features for consideration next year.

One feature that is not covered here in the report perhaps I ought to mention. The determining factor as regards the maximum height you would probably provide in your battery box would be a question of interference, particularly in third rail zones, and in discussing this phase of the report I am going to ask Mr. Lunn to make some remarks, as his company has made a rather extensive investigation of the subject in connection with a change of design in their box.

E. LUNN (Pullman Co.): Mr. Chairman, with reference to that question we have found 14⅞ in. over the rail, between the battery compartment and the top of the rail, to be satisfactory. That is the design limit and allows 2 in. for settlement. It permits a battery compartment having 24⅛ in. inside from top to bottom, about 4¾ in. over the top of the covers, which is sufficient to permit the flushing of the battery without the necessity of pulling the crate out of the compartment.

THE PRESIDENT: That dimension of 14⅞ in. that you refer to—is that the minimum distance that clearances will permit or is that simply a dimension used in your design?

MR. LUNN: As I understand it, that is the M. C. B. limitation—that it must have 14⅞ in. between the top of the rail and the bottom of the battery compartment. The battery box floor is just level with the top of the truss rod which we use on our steel underframe cars.

W. L. BLISS (U. S. Light & Heat Corp.): Mr. President, it was very gratifying to hear Mr. Billau state this morning that the specification on axle generators has been formally and officially adopted by the letter ballot,—I take it, by the members of the American Railroad Association. At the semi-annual meeting at Atlantic City there were a few points discussed that had not been thoroughly cleared up during the course of the preparation of the specification, and an attempt was made at that meeting to clear up those points and most of them were taken care of. There was one point, however, that was not taken care of, and was not cleared up to the satisfaction of everybody and that is to be found on page 370, item 1, under paragraph (i). After the Atlantic City meeting, Mr. Billau, who, I believe, was chairman of the committee, invited by means of letters which he wrote to the manufacturers of axle lighting apparatus, a further discussion of the point that I had just mentioned. I have here copies of three letters from manufacturers who are interested in the subject. George E. Hulse, representing one of the manufacturers, suggests that this clause read: "drop shall not exceed 2 volts at the rated capacity of the lamp regulator." W. F. Bouche's letter contains the following suggestions: "(a), when supply volts are less than 32, the drop across the lamp regulator shall not exceed 1½ volts at the rated load of the lamp regulator, and (b), when the supply volts are between 33 and maximum volts, the lamp regulator shall maintain its rated voltage plus or minus one volt at all loads from zero to the rated load of the regulator, it being understood that time for readjustments will be allowed after sudden changes of load or supply volts."

For my own part I think the clause should read like this: "The drop shall not exceed 2 volts with any current flowing less than 125 per cent of the connected lamp load or load to be handled by this lamp regulator."

TRAIN lighting specifications now become a part of the recommended practice of the American Railroad Association.

Battery boxes of increased depth are certain to meet with the approval of those who have the batteries to flush.

Electric repair shop facilities may seem expensive when first installed but their importance is such that the cost is soon forgotten in the resulting efficient operation and maximum production.

One direct current and one alternating current voltage if adopted as standard will greatly expedite electrical repairs.

The President: I might add a word to Mr. Bliss' remarks that when the committee received this additional information it considered it and felt that with the limited time available before the report must be presented to this association that it could not go into the subject with sufficient thoroughness to incorporate a revision in this year's report.

Mr. Macnab: Mr. Chairman, I would like to draw attention to one subject that is very live with us in Canada in the northern country and I fancy catches quite a few of the northern operating roads in this country too. That is the question of drive. As far as I know, up to date, one supply company manufactures a type of positive drive that has been applied to a few cars and I believe has given considerable satisfaction. In the winter time in our country, it is next to impossible to get the belt to drive and if any manufacturing company can come along with a reliable drive I think it would be very helpful. I would make the suggestion here that a sub-committee of the train lighting committee be instructed to investigate this subject and get some data together and, as it were, get some interest moving along those lines.

The President: Those suggestions will be taken into consideration in laying out next year's work for the committee.

It was then voted to accept the report and to have the committee continued.

Discussion of the Report on Electric Repair Shop Facilities

The President: This subject of repair shop facilities on railroads for electrical equipment is one of increasing importance. I think that this committee has covered the subject exceedingly well, and it certainly has given us some information on shop layouts that is far superior to what many railroads have available today. We would be glad to have any comments on the committee's report or suggestions as to what work might be taken up in the future.

A. H. Gerald (Pullman Co.): Mr. Lunn is rather modest and just suggested that if anybody is interested in the layout of our repair shops, he would be glad to lend them the prints. We have a repair shop at Buffalo and a good deal of thought was put on this particular plant. If anybody has an extensive electrical shop to lay out I am sure Mr. Lunn would be glad to work with him on that layout and we would be glad to let him have the plans on our particular shop for a good deal of money and time was spent on it.

Mr. Macnab: Mr. Chairman, I would like to say that the photographs and layout in this report are those of the Canadian Pacific shops at Angus, and any features or details that anyone present would like to have I will do what I can to answer any questions or personally give anyone any information possible with regard to the equipment we have there. Prior to getting this shop going, we had our electrical repair shop in the gallery. We found that extremely inconvenient from all standpoints. Motors and heavy equipment had to be transported on an elevator. Half the time the elevator would not take the load. We have had cases in which heavy motors have had to be put in through the window from a traveling crane outside. Galleries as a rule, too, are narrow and it is rather difficult to have sufficient space. One feature I would like to draw your attention to is to keep a heavy stock in conjunction with the shop so that you can handle the material without any delay, for if your material is all kept in the general stores it will cause a great deal of inconvenience.

J. E. Gardner (C. B. & Q.): Mr. Chairman, I would like to ask Mr. Macnab if he can tell us approximately how many motors there are in the repair shop at Angus, how many that shop takes care of, and if he can also tell us if there is any large amount of motors shipped in from outside points.

Mr. Macnab: I can say that we have got about 1,200 motors at Angus. They are 220 volts d. c. and 550 volts a. c., 60 cycles; the majority are 60 cycles. The shop also takes care of all the armature windings and coil windings for the eastern lines, that is, the lines east of Fort William, which is, I should say, about 7,000 miles.

E. H. Hagensich (Union Pac.): I might say that our shop at Omaha is practically this same layout. We take care of approximately 900 or 1,000 motors.

J. A. Andreucetti (C. & N. W.): I would like to ask in this motor repair work where you say you ship in from points on the road what you do in the meantime with the equipment that you take the motor off of?

Mr. Hagensich: We have spare motors for our collecting stations and turntables; at all the important terminals we carry spare motors and, of course, for the turntables you have got to carry a spare. For coaling stations and for power houses one spare will do for several places where the division points are not too far apart.

Mr. Andreucetti: It would seem to me that a proposition of that kind would be rather expensive where you have to carry an extra motor just to take care of an emergency; on the other hand it is a very expensive proposition when a coaling plant breaks down and you got to coal by hand for a week or more.

Mr. Hagensich: Most of our coaling stations are of the modern conveyor type and on the main line especially there is so much dissatisfaction if the coaling station is down that the management feels that every precaution should be taken and not only spare motors are carried but spare parts for the station so that there will be no excuse for the coaling station being down for any length of time.

Mr. Andreucetti: That one point shows the importance of hammering constantly at the management for standardization of motors for different parts of equipment. That has been our trouble; every other coal chute or turntable that we put in we get a different make of motor so that the templets are different and it is hard to get one motor to cover a half dozen of places.

Mr. Bebout: Mr. Chairman, I think the railroads ought to give the electrical repair department much more consideration in the shops than they generally do. While some shops have up-to-date electrical repair facilities I know a good many railroads have just a place fenced off that looks more like a junk yard than it looks like a repair shop. The roads should spend a little more money and give the men better places to work and the equipment to handle the business with.

Mr. Wanamaker: Mr. Chairman, I think the committee made a very good report in connection with the standardization of motor equipment. I would like to suggest that they look into standardized voltages. If you get down to one direct current and one alternating current voltage standard you will find it will help you quite materially. I would like to suggest that the committee be instructed to go very thoroughly into the methods of keeping the equipment continuously in service. What do the various roads do in handling their emergencies on all their electrical works for making repairs? What forms are used? What is considered telegraphic necessity and what is not? How much time is generally necessary for making repairs on field coils and circuit breaker parts? How much time is required to make repairs on rotors, stators and pinions on all these different motors? Where are they carried, how are they carried and who is kept informed on this matter? Is the Master Mechanic on the division familiar with it? Where are the spare parts kept? In other words, while the repair shop is the important thing and one which no doubt many railroads have lost sight of, the methods of handling your repairs and maintenance, it seems to me, are far more important. I think your committee could help me a great deal if they would go into these matters and get the present practices of some of the best railroads and then probably recommend a hypothetical one that we might all work to and adopt as being something near the ideal system.

The report was accepted and the committee continued.

Discussion of the Report on Power Trucks and Tractors

The final report of the convention on the subject of power trucks and tractors was presented on Friday morning by L. C. Moore, chairman of this committee.

L. C. Moore (Mo. Pac.): The committee has asked Mr. Hare to give you a little information on the question of power trucks and tractors. The committee felt that he was in a better position to talk to you than some of the rest of us.

K. R. Hare (Transportation Engineering Company): Mr. Chairman, I don't claim to be an expert in this tractor business, but I do go around and see a good many shop installations and freight house installations and talk to fellows that are running them, and you may be interested in a few of the results that these people seem to be getting.

There are three big classifications in railroad operation where you can use this type of vehicle; these are, freight houses, shops and store houses. The most popular model in the freight houses seems to be the three-wheeled tractor and in some cases the four-wheeled tractor; I might mention one particular installation where they are saving $50,000 a year and more. That is not an estimate, because the equipment that was put in is being paid for out of the savings made by it. That is the contract the people who put the installation in made with the company. They are saving the labor of about 40 men, with two tractors and 275 trailers.

In regard to shops, about two years ago it seemed to be the general opinion that the tractor was about the best type of vehicle for that installation, but I can see in general a change of ideas on that. The lift type of truck is being fitted to service wherever it is possible to use it. By the lift type I mean it is a load carrying truck where the platform itself raises and lowers according to how you press a certain lever and it operates in conjunction with some special form of skids or platforms. There are other trucks, special trucks with cranes on them and a hopper box, and special trucks for all kinds of service that can be used where there is work for them. The thing to be considered in the installation of a truck, after you have decided on the type, is that somebody should be on the ground who is sufficiently interested and of a progressive nature to give a good deal of his time, when they are first installed, because it is a new proposition. Every job is a special job and should be carefully studied. There are a whole lot of installations in the country that are not saving any money by tractor and trailer operation because they do not meet conditions on the job. You have got to go over these details when you are putting in the installation, if you do that it is going to be successful.

THE PRESIDENT: This subject is another one where the increased cost of railroads has made the question of labor saving devices an important feature for actual consideration. I think the committee has made an excellent start and it is the first attempt of our association to go into this particular subject to a very appreciable extent.

MR. HAGENSICH: I would like to ask if in your investigation you found many people using the gasoline truck?

MR. MOORE: Comparatively few. The gasoline truck seems to be used more by industrial concerns than it does by railroads.

MR. BEBOUT: Mr. Chairman, outside of electric and acetylene welding I do not know of anything that will pay the railroads more than the installation of trucks and tractors for handling materials. We have at one of our shops 9 or 10 of these trucks and they are always in service, they are always busy; we are figuring on more of them for this shop and for other shops. Unless, however, the railroads realize that good roads are a paying investment the trucks are not going to do as much as they should and your maintenance is going to be higher on trucks running around where you have no roadway. Good roadways are just as essential as anything else if you are going to handle trucks.

TRUCKS and tractors are making good—so good in fact that wherever they are once used the question arises, "How did we ever get along without them"?

Successful truck and tractor installations are always preceded by a careful analysis of the requirements. Special conditions call for special equipment.

System, with material handling apparatus as with everything else, makes for efficiency. Trucks and tractors operated as regular trains, handled by despatchers, indicate what the future practice with this equipment may become.

A. E. VOIGT (A. T. & S. F.): Speaking of the advantages to be gained by good roadways, had it not been for the installation of concrete roadways at Topeka we would not have been able to keep up with the handling of our batteries. Before we had these roadways we always had to remove our car lighting batteries in certain shops and we were quite often delayed in the neighborhood of one to two hours in getting the batteries out and getting them back in, on account of having to do this work just at certain times, and we found ourselves very short of space in the shop. Since the time that these roadways were installed around the shops it is immaterial to us when we take our batteries out because we always have access to them. I certainly appreciate the assistance that concrete roadways and electric trucks have given us in our work.

MR. MACNAB: Mr. Chairman, we have got a system at our Angus shops which I thought it might be worth while to mention at the meeting this morning. It is a system of despatching trucks. We have a truck despatcher. Since we have installed a despatcher he assigns the trucks to the various shops or he may assign several trucks. He does not despatch a truck for every trip it takes. We have only had it in operation for a very short time, a matter of a month or two, and possibly there may be a few more kinks in it that we will learn about before long.

E. W. JANSEN (Ill. Cent.): I was very much interested in Mr. Hare's statement about the number of replaced men with the tractor trucks. At our South Water street station in Chicago we handle about 1,700 tons per day. We have 9 tractors, 8 in regular use, so that they are handling something like 200 tons. They feel that from 8 to 10 men are saved by the use of a tractor.

MR. HARE: Mr. Chairman, I would like to add to Mr. Jansen's remarks by saying that in all my traveling around freight houses I have never seen an organization that handle their work as well as they do in the Illinois Central freight house at South Water street. They are working on this same principal of supervision and despatching. They have got the freight house divided up into what you might call divisions, like a railroad, and they have train masters. They have men make up the trains, they have conductors on the trains with a whistle. They have got the thing down to a very fine system. If anybody is interested in freight house operation it would be well worth their while to visit the South Water street station in Chicago.

MR. MOORE: I might mention one matter which seems to be overlooked in a great many installations, especially in the larger and more important ones, and that is having a spare machine. We are just going through the throes of trouble caused by not having one on our road. The freight house people in this case seemed to expect the machines to run indefinitely with only minor repairs. They would hardly expect a locomotive to be continuously in service for three or four years without shopping, but they do seem to expect that of a tractor.

MR. JANSEN: When we started out they expected these trucks to be in service every minute of the day. We showed them that there would be an hour or two at times at least when they would be out. We finally put in eight trucks and then had the ninth for reserve and now the ninth is used every afternoon and part of the morning. We need a tenth. Whatever you do add one to the number they ask for. These trucks operate 10 hours. We give the trucks a boost at noon for about 45 minutes. They start out about seven o'clock in the morning and work until 12:15 and from one to six or six-thirty. I can't think of the miles that they make just now. but I think the tractors are moving 80 per cent of the time.

It was then voted to accept the report of the committee and have the committee continued.

Election of Officers

Immediately following the presentation of the final committee report the election of officers took place with the following results: President, L. C. Hensel, St. Louis-San Francisco; Senior Vice-President, E. S. M. Macnab, Canadian Pacific; Junior Vice-President, Ernest Lunn, Pullman Company. The two new members elected to the Executive Committee for the ensuing year are C. R. Sugg, Atlantic Coast Line; and E. Marshall, Great Northern. In keeping with the recently adopted amendment to the constitution a nominating committee was elected consisting of L. S. Billau, J. E. Gardner, E. W. Jansen, J. L. Minick and E. Wanamaker.

Railroads Represented

Atchison, Topeka & Santa Fe—H. A. Franch, Topeka, Kans.; H. G. Myers, Oak Park, Ill.; A. E. Voigt, Topeka, Kans.

Atlantic Coast Line—C. R. Sugg, Wilmington, N. C.

Baltimore & Ohio—L. S. Billau, Baltimore, Md.; W. E. Buckmaster, Chicago, Ill.; C. L. Colley, Cumberland, Md.; G. E. Hauss, Cincinnati, Ohio; W. L. Heald, Baltimore, Md.; G. A. Leisinger, Garrett, Ind.; W. W. Leonard, Baltimore, Md.; R. P. Moran, Cincinnati, Ohio; L. C. Muelheim, Baltimore, Md.; C. W. Price, Baltimore, Md.; J. H. Smeltz, Cumberland, Md.

Bessemer & Lake Erie—E. R. Mertz, Greenville, Pa.

Boston & Maine—P. J. Callahan, Boston, Mass.

Canadian National—G. Salmon, Winnipeg, Man.

Canadian Pacific—E. S. M. Macnab, Montreal, Que.

Central of Georgia—J. C. McElric, Savannah, Ga.

Chesapeake & Ohio—G. W. Bebout, Richmond, Va.; W. J. Connolly, Covington, Ky.; F. C. Watson, Huntington, W. Va.

Chicago & Alton—A. Abramic, Chicago, Ill.

Chicago & Eastern Illinois—J. H. Burchain, Danville, Ill.

Chicago & Great Western—G. R. Shirk, Oelwein, Iowa.

Chicago & Northwestern—J. A. Andreucetti, Chicago, Ill.; G. C. Beard, Beloit, Wis.; G. L. Brouk, Chicago, Ill.; L. Bucholtz, Milwaukee, Wis.; W. Chapman, Chicago, Ill.; R. Daniels, Chicago, Ill.; A. J. Farrelly, Chicago, Ill.; A. J. Johnson, Chicago, Ill.; A. A. Kemp, Chicago, Ill.; C. P. Marshall, Chicago, Ill.; E. S. Monson, Milwaukee, Wis.; I. Peters, Hollywood, Ill.; L. W. Stephens, West Chicago, Ill.

Chicago, Burlington & Quincy—J. R. Dreset, Lincoln, Neb.; W. H. East, Chicago, Ill.; G. C. Elbreder, St. Louis, Mo.; J. E. Gardner, Chicago, Ill.; L. S. Lewis, Aurora, Ill.; F. McGary, La Grande, Ill.

Chicago, Milwaukee & St. Paul—J. J. Crowley, Milwaukee, Wis.; C. R. Gilman, Milwaukee, Wis.; E. Sass, Chicago, Ill.; M. Schwartz, Milwaukee, Wis.

Chicago, Rock Island & Pacific—R. F. Beazley, Chicago, Ill.; L. C. Bowes, Chicago, Ill.; E. R. Chinberg, Kansas City, Mo.; J. G. Eberle, Chicago, Ill.; H. W. Gammell, Chicago, Ill.; A. E. Gansert, Chicago, Ill.; A. G. Mueller, Valley Junction, Iowa; H. R. Pennington, Chicago, Ill.; F. Roblin, Joliet, Ill.; L. D. Smith, Silvis, Ill.; R. J. Smith, Horton, Kans.; C. Victor, Kansas City, Kans.; E. Wanamaker, Chicago, Ill.

Chicago, Terre Haute & Southeastern—W. R. Madden, Terre Haute, Ind.

Chicago Union Station Company—A. Gollos, Chicago, Ill.

Colorado & Southern—H. E. Hinds, Denver, Colo.

Delaware & Hudson—G. Dodds, Albany, N. Y.

Denver & Rio Grande—H. L. Armstrong, Denver, Colo.; H. A. Goodridge, Denver, Colo.

Detroit & Mackinac—G. F. Ash, East Tawas, Mich.

Duluth & Iron Range—J. Beck, Two Harbors, Minn.; N. W. Rose, Duluth, Minn.

Duluth, Missabe & Northern—T. H. Bell, Proctor, Minn.; A. M. Frazee, Duluth, Minn.

El Paso & Southwestern—B. C. Evans, El Paso, Texas.

Fort Worth & Denver City—O. W. Norris, Fort Worth, Texas; R. M. Weston, Fort Worth, Texas.

Grand Trunk System—E. M. Glass, Port Huron, Mich.; G. E. Murray, Battle Creek, Mich.

Great Northern—E. Marshall, St. Paul, Minn.

Illinois Central—G. A. Broshand, Paducah, Ky.; G. B. Colegrove, Chicago, Ill.; G. T. Goddard, Chicago, Ill.; E. B. Grace, Memphis, Tenn.; C. A. Jansen, Chicago, Ill.; E. W. Jansen, Chicago, Ill.; T. A. Johnson, Paducah, Ky.; F. A. Krissling, Chicago, Ill.; J. F. Lahndorff, Freeport, Ill.; J. D. Younger, Chicago, Ill.

Indiana Harbor Belt—A. E. Greenawalt, Gibson, Ind.

International & Great Northern—J. W. Jones, Palestine, Texas.

Kansas City, Mexico & Orient—A. R. Hanson, Wichita, Kansas.

Kansas City Terminal—W. J. Dawson, Kansas City, Mo.; R. Gaegnet, Kansas City, Mo.

Louisville & Nashville—C. L. Kincaid, Louisville, Ky.; M. B. Wilson, Memphis, Tenn.

Memphis Union Station Company—W. A. Lanahan, Memphis, Tenn.

Michigan Central—H. A. Bisbee, Jackson, Mich.; C. W. Cooke, Jackson, Mich.; J. Fogarty, Jackson, Mich.; F. J. Hill, Detroit, Mich.; J. L. Ohmons, Chicago, Ill.; R. C. Raether, Albion, Mich.; E. E. Seger, St. Thomas, Mo.; C. G. Winslow, Detroit, Mich.

Minneapolis & St. Louis—R. W. Folkenson, St. Paul, Minn.

Minneapolis, St. Paul & Sault Ste. Marie—S. D. Dimond, St. Paul, Minn.; J. R. Smith, Minneapolis, Minn.

Missouri Pacific—E. H. Bradshaw, Little Rock, Ark.; O. J. Hoeschulle, St. Louis, Mo.; L. Moore, St. Louis, Mo.; J. O. Pilger, St. Louis, Mo.; J. B. Waters, Kansas City, Mo.

New York Central—A. McGary, New York, N. Y.

New York Central Lines West—H. C. Meloy, Cleveland, Ohio; G. M. Pinkney, Cleveland, Ohio; H. E. Thompson, Collinwood, Ohio; I. R. Wintworth, Cleveland, Ohio.

New York, New Haven & Hartford—F. Zimkowski, New Haven, Conn.

Oregon Short Line—J. S. Woffington, Pocatello, Idaho.

Pennsylvania System—E. W. Breese, Chicago, Ill.; C. J. Causland, Chicago, Ill.; W. H. Evans, Indianapolis, Ind.; E. M. Fitz, Columbus, Ohio; E. C. W. Geistert, Grand Rapids, Mich.; J. L. Minick, Altoona, Pa.; F. C. Needham, Terre Haute, Ind.; J. R. Sloan, Pittsburgh, Pa.; C. W. T. Stuart, Philadelphia, Pa.

Pere Marquette—C. McDermott, Grand Rapids, Mich.

Pittsburgh & Lake Erie—S. B. Pickard, Pittsburgh, Pa.

Pullman Company—A. H. Gerald, Chicago, Ill.; E. Lunn, Chicago, Ill.
St. Louis-San Francisco—L. C. Hensel, Springfield, Mo.
Union Pacific—E. H. Hagensich, Omaha, Nebr.
Virginian Railway—E. A. Stecker, Princeton, W. Va.
Wabash Railway—J. A. Cooper, Decatur, Ill.
Yazoo & Mississippi Valley—E. B. Grace, Memphis, Tenn. (Also headlight inspector on Illinois Central.)

Railway Electrical Supply Manufacturers' Exhibit

An Excellent Display of New and Improved Equipment Aroused the Interest of Railroad Men

THE exhibit of the railway electrical supply manufacturers which was held under the auspices of the association of the same name at the twelfth annual convention of the Association of Railway Electrical Engineers in the Auditorium Hotel, Chicago, on October 18 to 22 inclusive, was a remarkable and most successful one. The Manufacturers' Association arranged for the largest and most complete exhibit and program of entertainment that has ever been prepared in connection with this event. The officers of the executive and arrangement committees are to be congratulated upon the results of their work. The businesslike manner in which the exhibits were displayed and demonstrated to inquiring parties had much to do with the enthusiastic interest on the part of every railroad man in attendance at the convention.

Although the membership of the Railway Electrical Supply Manufacturers' Association is comparatively small (consisting of 44 companies with approximately 125 members) the enthusiasm and willingness to serve is tremendous. Out of the 44 companies who are members of this association there were 36 companies who maintained booths and exhibited devices used by the railroads in the electrical and mechanical departments. In most every case the supply manufacturers exhibited only those devices and appliances which are of the greatest interest to the railroad men who usually attend such conventions. Some of the companies exhibited, for the first time, appliances for use in the railroad electrical field.

Election of Officers

Promptly at 10:30 o'clock on Thursday morning, October 21, the Railway Electrical Supply Manufacturers' Association held its annual meeting for the election of officers for the ensuing year. The officers elected are as follows: President, F. V. McGinnis, Transportation Engineering Corporation, New York; senior vice-president, Daniel Woodhead, Central Electric Company, Chicago; secretary, J. Scribner, General Electric Company, Chicagi; treasurer, Edward Wray, *Purchases and Stores,* Chicago.

The new members of the Executive Committee, elected this year to serve for three years are: J. W. Porter, Electric Service Supply Company, Chicago; George H. Scott, Safety Car Heating and Lighting Company, Chicago, and Otto Danielson, Western Electric Company, Chicago. The other members of the Executive Committee who still have one or two years to serve are: B. G. Durham, A. & J. M. Anderson Company, Chicago; J. C. Campbell, Sunbeam Electric Manufacturing Company, Chicago; F. F. Skeel, Crouse-Hinds Company, Chicago; J. Will Johnson, Pyle National Company, Chicago; George R. Berger, Gould Coupler Company, Chicago and R. L. McLellan, Westinghouse Electric & Manufacturing Company, Chicago.

Companies Exhibiting

The 36 companies maintaining booths and exhibiting their devices are as follows:

Albert & J. M. Anderson Manufacturing Company, Boston, Mass.—Complete line of charging plugs and receptacles for yard charging plants and car equipment; line of plugs and receptacles for arc welding purposes, both for direct current and alternating current circuits, including double, triple and four-pole type with various forms or mountings, line of plugs and receptacles for locomotive headlight work; various watertight special type, single, double and triple-pole plugs and receptacles for light and power work on docks and similar places. Represented by B. G. Durham, Chicago.

Allen Bradley Company, Milwaukee, Wis.—This company exhibited a battery charging switch board, type L-1210, a. c.; automatic motor starters, type J-1602; hand operated a. c. motor starter, type H-1990; crane, hoist or turntable controller, either a. c. or d. c., type F-2300; I. T. L. overload relay, a. c. or d. c. N-301. Represented by H. L. Bradley, G. O. Wilms, R. Fishback, Milwaukee, Wis., and F. L. Gohl, Chicago.

American Metal Products Company, Brooklyn, N. Y.—Exhibited new lightweight non-corrosive headlight; gage lamps; receptacle and connection boxes. Represented by N. A. Levetan and A. C. Cooper.

Benjamin Electric Manufacturing Company, Chicago.—Exhibited a line of headlight sockets, watertight attachment plugs, watertight lighting fixtures, and porcelain enamel steel reflector for industrial illumination. Various styles of lighting panels and a line of marine fittings for railway and steamship use. Represented by C. L. Johnson, W. J. Goodrich and E. A. Detrick of Chicago and M. J. Cleary of St. Louis.

Bryant Electric Company, Bridgeport, Conn.—This company displayed a Bryant hospital signal station operating on 110-volts or on 220-volts; a complete line of socket receptacles, plugs, cartridge cutouts and interconnecting blocks; watertight and non-watertight plugs and receptacles; panel switches with connections for plug fuses and cartridge fuses; plug cutouts, conduit fittings, and a line of threaded cap sockets. Represented by W. O. Dahlstrom, Ward Thomas and V. B. Habryl of Chicago; also George Williams of New York.

Bussman Manufacturing Company, St. Louis, Mo.—This company exhibited all types of fuses, reversible and non-reversible cartridge fuses; open link fuses; fuse wire and plug fuses. Represented by F. E. Lauderbach, St. Louis, Mo.

Central Electric Company, Chicago.—Line of "Ralco" plugs and receptacles for battery charging and power service for use in shops, yards, power stations, locomotive and car wiring; "Okonite" wires and cables; "Okonite" and "Manson" tape; "Maxolite" reflectors and sockets; Four-In-One light fixtures for station and office lighting; D. & W. renewable fuses; Deltabeston wire for armature winding, heater cords and asbestos covered products; flexible hose armor ⅜ in. to ½ in. for locomotive and car wiring, also G. E. car fans. Represented by Dan Woodhead, J. M. Lorenz, R. N. Baker, A. L. McNeil, L. R. Mann, and E. H. McNeil of Chicago. Okonite representatives, W. R. Van Steenburgh and F. J. White of New York.

Chicago Fuse Manufacturing Company, Chicago.—Displayed its line of enclosed fuses, all types and sizes, refillable and non-refillable. Also outlet and gear box line. Represented by H. P. Collins and T. C. Walsh of Chicago.

Crouse-Hinds Company, Syracuse, N. Y.—This company exhibited a complete line of imperial flood lighting projectors. Condulets for all purposes; plugs and receptacles for arc welding and power service; complete line of locomotive wiring condulets for electric headlight service; also lamp guards, and safety switches. Represented by F. F. Skeel, E. C. Otto, E. N. Bigley, E. A. Hurlbut and Charles Dubsky of Chicago; E. G. Smith, K. W. Mackall, A. F. Hills, W. L. Hinds and C. H. Bissell of Syracuse, N. Y.; J. B. Wilmott, St. Louis, Mo.; A. B. McChesney, Detroit, Mich.; A. B. Coffman, Philadelphia, Pa.; A. E. Vilan, Minneapolis, Minn.; Frank Gerhardt, San Francisco, and H. McIntyre, New York.

Dodge Sales & Engineering Company, Oneida, N. Y.—Displayed its "Keystone" car lighting axle pulley and "Oneida" corrugated bushings. Represented by N. G. Stark.

Edison Storage Battery Company, Orange, N. J.—This company exhibited Edison nickel-iron car lighting batteries. A portion of the cells exhibited were cut away to show all of the structural details; miniature train showing train lighting and signals. Represented by D. C. Wilson, A. S. Knox, and A. M. Anderson, Chicago and W. W. Coleman, New York.

Electric Service Supply Company, Philadelphia, Pa.—This company exhibited its Golden Glow and Keystone locomotive headlight equipment; coil winding, forming and taping equipment; line insulators; industrial current collecting specialties and commutator undercutting tools. The headlight exhibit consisted of the following: Type L. B. C.-1412 one-piece cast iron headlight case with 14-in. Golden Glow mirror reflector; new type L. B. N.-1412 one-piece cast iron headlight case with number boxes on the side equipped with Golden Glow adapter unit. This adapter unit fits in standard 18-in. by 9-in. case and is equipped with 14-in. Golden Glow glass mirror reflector. Type F. L.-1412 headlight case with Golden Glow mirror reflector and 500-watt concentrated filament lamp; type F. L.-1419 flood light case with Golden Glow mirror reflector and 1,000-watt mazda standard C lamp; type M. L. C-96 cast iron headlight case used for yard locomotive service with 9-in. Golden Glow mirror reflector; type L. B. N. V-1412 copper headlight case with number boxes at angle on side equipped with 14-in. Golden Glow mirror reflector; U. S. standard headlight case equipped with Golden Glow adapter unit with 14-in. Golden Glow mirror reflector; in addition this company showed a display of Golden Glow reflectors to illustrate the process of manufacture from the glass to the completed product, in both 14 and 16 in. diameters, a Keystone turbo-generator type 532-500-watt, 32 volts, with parts of frame cut away to show valves, governor and other working parts, also Keystone locomotive headlight switches of different types for all ordinary operating conditions. Represented by C. J. Mayer, J. R. McFarlin, L. A. Darling and R. S. Levis of Philadelphia; J. W. Porter, Max A. Berg, L. J. Kirby, T. M. Childs, and B. D. Barger of Chicago.

Electric Storage Battery Company, Philadelphia, Pa.—This company's display included the following: A set of Manchester positive plates which had been in operation for eight years during which time they had been in service for over 1,355,000 miles; also car lighting batteries assembled in giant rubber jars with double flange alloy cover and batteries for railway signal service. The Exide Iron Clad battery for electric locomotives trucks and tractors was also shown. A standard truck type axle generator, also the body hung generator; the latter was provided with the new belt tension adjusting device of the lever type. Represented by J. L. Woodbridge, Thomas L. Mount and H. E. Hunt of Philadelphia; G. H. Atkin, T. Milton, O. R. Shortall and H. M. Beck of Chicago.

Fairbanks, Morse & Company, Chicago.—Exhibited type H sectionalized ball bearing squirrel cage alternating current induction motor; rotor cages with cast-on-end rings and type C. C. starter for squirrel cage motors with oil-immersed switch mechanism and transformers. A sectionalized starter wheel for Fairbanks Morse internal starter motor, also a line of ball-bearings and samples of doublewear renewable finger tips. Represented by M. O. Southworth, F. M. Condit, Joseph Dandie, P. H. Gilleland and A. A. Taylor of Chicago; H. E. Vogel, Baltimore, and E. Lang, N. Y.

General Electric Company, Schenectady, N. Y.—One of the features of this exhibit was an arc welding equipment (Type W D-9 portable set) produced by the General Electric Company. In addition there was exhibited a turbo-generator set (type C Y-32-B 500-watt 32-volt), switchboards and equipment for charging train lighting and baggage truck batteries. Represented by W. M. B. Brady, C. Dorticos, G. F. Bunn, of Chicago; C. C. Baily, J. Roberts, B. C. Tracey, H. M. Jacobs and C. T. McLaughlin of Schenectady, and C. B. Keys, New York, N. Y.;

R. Hughes, St. Louis, Mo.; F. P. Jones, Philadelphia, Pa., and J. H. Liles, Baltimore, Md.

Gould Coupler Company, New York.—This company exhibited adapter body type suspension. Type B. B.-9-B generator regulator; type AB-9-B combination generator and lamp regulator; type M-2 lamp regulator; type M-3 lamp regulator; a full working set direct drive for car lighting generator; a turbo-generator for locomotive headlight (500-watt 32-volt a. c.); double compartment unit, set up with chemically pure plated wood separators rubberized. Represented by W. F. Bouche, M. R. Shedd, of Depew, N. Y.; P. H. Simpson, New York; G. R. Berger of Chicago.

Hart & Hegeman Manufacturing Company, Hartford, Conn.—This company exhibited lamp guards, snap switches of various sizes and porcelain receptacles for industrial and office lighting. It also displayed the "Paiste" line of pipe taplets. Represented by W. W. Winship, and A. Lubeck, of Chicago.

Hazard Manufacturing Company, Wilkes-Barre, Pa. This company exhibited special wires and cables, headlight wire, spiral-weave cable, steel-taped cable, spiral weave extension cord and an exhibit showing manufacture from crude products to finished wires and cables. Represented by T. A. Keefe, Pittsburgh, H. B. Pflasterer, George P. Cady, and W. S. Hart, Chicago.

The Kerite Insulated Wire & Cable Company, Inc., New York.—Exhibited samples of power cable, charging cable, headlight wire with special braid finish, building and car wire, plain battery connector cable and ignition wire. Represented by Azel Ames, J. W. Young, and P. W. Miller of New York; E. L. Adams, J. A. Hamilton, W. H. Fenley and C. A. Reeb of Chicago and G. A. Graber of Atlanta, Ga.

Loco Light Company, Indianapolis, Ind.—This company exhibited type M 500-watt headlight generator and 18 in. by 9 in. headlight case. Represented by H. H. Tomlinson, and Chris Vossler, Indianapolis.

National Lamp Works of the General Electric Company, Cleveland, Ohio.—This company exhibited a reflector cap defusor, train and locomotive headlight lamps, a portable foot candle meter, which is self-contained, for reading foot candles direct from any position. Represented by C. W. Bender, J. E. Heeter and G. E. Park, Cleveland, Ohio. The Ivanhoe Works of the General Electric Company was represented by L. C. Doane.

New Jersey Car Spring & Rubber Company, Jersey City, N. J.—This company exhibited car spring axle generator belt and M. C. B. air brake hose. Represented by Geo. J. Dunn.

Oliver Electric & Manufacturing Company, St. Louis, Mo.—This company exhibited locomotive headlight wiring appliances, such as headlight switches, toggle switch, terminal boards, junction boxes, plugs and receptacles, flexible conduit couplings, cab lighting fixtures and tender signal lamps, plugs and receptacles for shop wiring, terminal boxes, train line plugs and receptacles for car lighting, safety first switches; electric marker and classification lamps. Represented by J. A. Amos, W. M. Graves, Jr., Charles Gelan, and W. A. Ross of St. Louis, Mo.

Pyle National Company, Chicago.—Exhibited turbines, as follows: Three to 10-kw. type M for train lighting; new type D 500-watt headlight turbo-generator and a new type A 500-watt a. c. turbo-generator; also standard 16-in. cast iron case with glass mirror reflector and government standard 18-in. headlight case with 18 by 9 in. copper silver plated reflector. Represented by R. L. Kilker, Atlanta, Ga.; J. L. Reese and Robert Shaal, New York; A. R. Allen, Kansas City, George E. Haas, William Miller and J. Will Johnson, Chicago.

Railway Electrical Engineer, New York.—At this booth were copies of the *Railway Electrical Engineer* and other publications issued by the Simmons-Boardman Publishing Company, including the Locomotive Dictionary and Cyclopedia and Car Builders' Dictionary and Cyclopedia. Represented by A. G. Oehler, C. J. Corse, R. F. Duysters and F. H. Behrens, New York; J. M. Rutherford, B. J. Wilson, E. A. Lundy and B. W. Meisel, of Chicago.

Safety Car Heating & Lighting Company, New York.—This company exhibited underframe axle equipment with various types of regulating appliances and a few car lighting fixtures and fans. Among their regulators appeared the type F lamp and generator regulator, type FF generator regulator, the type F-1 lamp and generator regulator and the type F-R lamp and generator regulator. Represented by J. H. Rodger, C. A. Pinyerd and G. H. Scott, of Chicago; J. S. Henry, H. K. Williams and A. V. Livingston, of New York; and J. L. Marsh, of Philadelphia, Pa.

S. K. F. Industries, Inc., New York.—This company showed a line of Hess-Bright and S. K. F. types of ball-bearings for car lighting and headlighting work. The various sizes generally adopted by manufacturers of car lighting and headlight generators and headlight equipment were shown. Photographs were used to show the actual application of such ball-bearings as used in the railway field. Represented by R. E. Hine, Milwaukee, Wis., F. J. Rider, Minneapolis, and J. B. Castino, Chicago.

Square D. Company, Detroit, Mich.—This company exhibited safety switches—also the use of safety switches illustrated by moving pictures. Represented by R. J. Bueter, Detroit, Mich.; H. L. Fritschle, Russell Murphy and J. A. Wagner, Chicago.

Stone Franklin Company, New York.—Exhibit consisted of single battery equipment and A. R. panel. Represented by R. G. Coburn, C. E. Walker, J. L. Hays and H. D. Rohman of New York; R. Gerrard and W. L. Gray, Montreal, and E. Gallagher, St. Louis.

Sunbeam Electric Manufacturing Company, Evansville, Ind.—The R. E-3 turbo-generator and U. S. standard locomotive headlight together with various parts of this apparatus was exhibited by this company. Represented by W. A. Carson, L. B. Jones and J. Henry Schroeder, of Evansville, Ind.; F. W. Edmunds, W. F. Manogue, New York; H. A. Varney and C. E. Kinnaw of Chicago.

Thompson Electric Company, Cleveland, Ohio.—This company exhibited a new type of safety cutout hanger for hanging large industrial lamps in shops, roundhouses, yards and also for depot lighting. Represented by A. J. Thompson, Cleveland, Ohio.

Transportation Engineering Corporation, New York.—

This company exhibited electric trucks and tractors for railroad service. Rochlitz automatic water stills, battery charging equipment, and Wanamaker coated electrodes for electric arc welding. Represented by K. R. Hare, Chicago.

U. S. Light & Heat Corporation, Niagara Falls, N. Y.—This company exhibited various types of car lighting regulating apparatus including the ampere hour meter, also a small baggage car and coach equipment including complete regulating apparatus. A 1½-kw. body-hung, generator was shown, as well as samples of diagonally ribbed swedged battery plates, armature shafts, terminal boxes, and a cutaway generator showing the complete construction of such a machine. This company also exhibited samples of arc welding work, electrode holders, face shields and accessories. They distributed copies of a new bulletin and treatise on arc welding. An actual working exhibit was maintained at the U. S. L. Service Station, 3845 South Wabash Avenue, where demonstrations were carried on for the benefit of those who wished to avail themselves of the opportunity. Represented by W. L. Bliss, H. A. Matthews and Geo. Kyle of Niagara Falls; E. C. Wilson and H. A. Morrison of Chicago, and O. R. Hildebrant, Washington, D. C.

V. V. Fittings Company, Philadelphia, Pa.—This company exhibited reversible conduit fittings and safety switches. Represented by Dana Fisher, William F. Cleff, A. K. Johnson and John Byrnes.

Western Electric Company, New York—Displayed the W. E. railroad flood lighting lamp and portable utility light for railroad use; also sunbeam lamps for all purposes. Habirshaw products were also exhibited including Habirlite locomotive headlight wire and cable light cord, railway signal wire, sector and concentric power cables and submarine cables. Western Electric representatives were George Hull Porter, O. C. Danielson, Chicago; G. J. McCall, Omaha; A. W. Hillis, Detroit; J. A. Casey, St. Louis; A. L. Frankenberger, St. Paul; Bob Evans, American Lighting Company, Chicago, and Habirshaw representatives A. L. Crater, C. R. Wharton, New York and F. C. Jaeger, Philadelphia, Pa.; E. W. Kearns, Chicago; R. Eves, Cincinnati, Ohio; L. R. Day, Milwaukee, Wis.; T. J. Wheatley, Cleveland, Ohio; P. Hansen, Minneapolis, Minn.; J. G. McNeely, Pittsburgh, Pa.; George Newcomb, Electro-Magnetic Tool Company, Chicago and W. Kingsley, Duracord Company, Chicago.

Westinghouse Companies: Exhibitors of portable arc-welding equipment, 175 amperes, separately excited; numerous welding samples, flood lights, headlights, industrial and signal lamps, color light signal, 500-watt turbine head lighter, 5 hp. new type "HK", hoist and crane motor, type "C" d. c. automatic controller, and various types of starting equipments. Represented by G. H. Jaspert, R. L. McLellan, J. M. Pfeil, Norman Stewart, Messrs, Kelly, Hibbon, and Blown.

American Railway Association announces that the report for Oct. 1 shows that progress is being made in returning cars to home lines. There was a 2 per cent gain from Sept. 1 to Oct. 1 when the figure was 30 per cent.

Electrification of the English Railroads

The Electrification of Railways Advisory Committee appointed by the Minister of Transport in Great Britain for the purpose of inquiring into the electrification of railways has made its first preliminary report. The personnel of this committee has already been published in these columns.

The committee has held 28 meetings and has had before it as witnesses representatives of the various English railways interested in electrification, representatives from various electrical contractors in Great Britain and in addition Ivan Ofverholm, the chief electrical engineer of the Swedish State railways and Col. Huber-Stockar, consulting engineer to the Swiss State railways.

From information obtained from these witnesses and from questionnaires sent out to the chief railway companies, the committee has prepared full statistical tables which have been given detailed consideration. In this first report the committee covers certain general points, the more detailed problems being left over for a subsequent report.

Instructions to the Committee

The instructions to the committee by the Minister of Transport were to consider:

1. Whether any regulations should be made for the purpose of ensuring that the future electrification of railways in this country is carried out to the best advantage in regard to interchange of electric locomotives and rolling stock, uniformity of equipment and other matters.

2. If any such regulations are desirable, what matters should be dealt with, and what regulations should be made.

3. How far it is desirable, if at all, that railways or sections of railways already electrified should be altered so that they may form parts of a unified system.

The Recommendations Made

In respect to item 1, the committee considers it is desirable that certain general regulations should be made for observance by the railways when electrifying their lines, insuring standardization of those methods and appliances which are likely to prove the most satisfactory under British conditions. At the same time, such regulations should put no avoidable difficulties in the way of the adoption in future of any improvements in methods or appliances which may from time to time become available with increasing knowledge and experience.

In respect to item 2, the committee recommends that regulations should be issued in accordance with the following conditions:

(1) That in the case of those railways which have not as yet electrified any lines, as well as those which at present have electrified all or part of their lines on a direct current system, their electrification, or extended electrification, as the case may be, should be carried out on the direct current system.

(2) That the standard pressure of the direct current system at the sub-station busbars shall be 1,500 volts, subject to—

(a) The continuance of any existing 600 volt or 1,200 volt installations.

(b) The adoption of half the standard voltages—750 volts—in those cases where it can be shown that advantage would arise from the use of this lower pressure.

(c) The adoption of higher pressures—limited to a multiple of the standard pressure—where it can be shown that sufficient advantage would accrue.

(3) That both overhead and rail conductor collection should be permitted, as long as the position and general design of the conductors and structures are in accordance with recommendations which will be made in a subsequent report.

(4) That the generation of current for direct current lines should be alternating three-phase at such voltage as may be desirable in each case.

(5) That in the case of existing generating stations supplying at any frequency between 25 and 50 cycles it is unnecessary to make any change in frequency, but that it is desirable that where any one such frequency is in general use in a particular electricity district, any new power station put down in that district for supplying a railway should adopt the frequency which has been approved by the electricity commissioners or is in general use in that district.

In respect to item 3, the only line of any importance in Great Britain which would not come under the terms of the committee's recommendations outlined above, is the London, Brighton & South Coast. This road has adopted a single phase alternating current system for its suburban lines and did so with a special view to the adoption of a system which at that time appeared the only one admitting of extensions from London to Brighton when this extension became feasible. In this particular case the committee had to consider that with the present system on the Brighton a change of locomotives or multiple-unit equipment would be required in case other railway companies were to run trains over that line. On the other hand a large financial expenditure would be required to change the existing suburban system of the Brighton to a direct current system. The committee therefore decided that the Brighton system as at present in use or actually under consideration need not be changed and that the proposed extension of the electrified portion of this railway to Brighton is one for special consideration.

Western Electric-Hawthorne Plant Inspection

On Friday, October 22, the Western Electric Company conducted an inspection trip through its Hawthorne works at Chicago. About 150 were present. The party was composed largely of railway men engaged in various capacities in the railway electrical field who had been in attendance at the annual convention of the Association of Railway Electrical Engineers held at the Auditorium Hotel, Chicago, from October 19 to 22, inclusive. The party included also, several representatives from railroad signal departments and railway supply men.

The delegation left the Auditorium Hotel at noon on October 22, and were taken by bus and automobile to the Hawthorne works at West 22nd and Cicero avenue. Upon arriving there, the party inspected the power plant, after which a luncheon was served in the main dining room. An excellent musical program was furnished by the employees' orchestra, and vocal selections were rendered by a trio of male voices and several solos by women.

The afternoon was devoted to an inspection of the production facilities afforded for the manufacture of cable and telephone appliances. The group picture shows the party assembled prior to the inspection.

Briefly the facilities of this plant are as follows:

Fire Protection: One 5,000,000 gal. reservoir; three tanks in water tower 175,000 gal. combined; fire pumps, underground piping, hydrants, sprinklers, etc.

Boilers: Twelve-rated at 800 hp.

Coal: During 1919 consumed 90,000 tons for the generation of 1,300,000,000 lb. of steam and 29,880,000 kw. hrs.

Turbo Alternators: One 2,000 kw. 440 volts; two 3,000 kw. 440 volts; one 750 kw. 440 volts; one 1,500 kw. 440 volts; one 5,000 kw. 440 volts.

Turbo Exciters: Four 75 kw.

Rotary Converters: Three 500 kw. 440 a.c. 220 and 115 d. c.

Air Compressors: One 90 lb. 2,500 cu. ft. per min. steam driven; one 90 lb. 1,000 cu. ft. per min. steam driven; one 90 lb. 500 cu. ft. per min. motor driven; one 30 lb. 5,000 cu. ft. per min. steam driven—(sand blasting); one 800 lb. 1,000 cu. ft. per min. motor driven—(locomotive).

Floor Area: Telephone appliance shops. 1,992,968 sq. ft.; cable plant 481,000 sq. ft.; service buildings 116,000 sq. ft.; merchandise buildings 327,000 sq. ft.; restaurant 34,000 sq. ft.; foundry 89,000 sq. ft.; total 3,104,000; 97 acres, main buildings; 45 acre lumber yard and 10 acre athletic field.

Employees: 22,000.

Drinking Water: One 96-in. Jewel filter; capacity 79,000 gal. lake water per hour; one refrigerator machine, capacity 80 ton; drinking fountains on all floors of buildings.

Group of Interested Visitors Who Inspected the Facilities and Operation of the Western Electric Company's Hawthorne Works

Alternating Current Magnetic Controllers

Inherent Characteristics of Apparatus Differ Greatly from Those of Direct Current Equipment

By Gordon Fox

THE alternating current magnetic controller resembles its direct current prototype in that it comprises an assembly of contractor and relay units working in combination. In other details, however, direct and alternating current magnetic controllers differ materially.

The alternating current magnet differs from the direct current magnet in that it is excited by a pulsating current. This introduces several complications. In order to minimize iron losses in the magnet coils giving rise to heating, it is necessary that the magnetic circuits be entirely or largely built up of laminations. In a direct current magnet the coil resistance alone determines the current flow through a magnet coil under a given voltage. In the case of an alternating current magnet reactance plays an important part. The reactance is a function of the magnetic air gap, hence it varies according to the position of the plunger or armature. As the exciting current of a direct current contactor magnet remains constant the magneto-motive force is constant. The pull on the armature varies as the square of the air gap; thus, as the contactor closes the pull increases rapidly, tending to seal the contactor firmly. As an alternating current contactor closes, its coil reactance increases and the power of the coil decreases. This tends to offset the tendency for the pull to increase as the air gap is lessened. The sealing power of an alternating current contactor magnet is relatively low. The current through the magnet coil with the contactor closed is only about one-fifth of the flow with the contactor open.

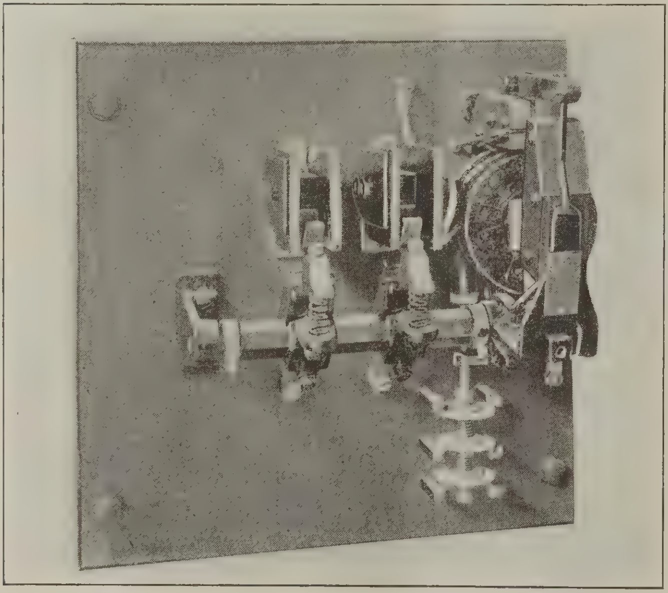


Fig. 1—Two Pole Alternating Current Magnetic Contactor Unit

The pull of the magnet of a direct current contactor is continuous, there is thus no tendency to chatter. An alternating current contactor energized by a single phase coil, carries a flux which passes through zero at every reversal of the current. This leads to a tendency to chatter. This tendency is relieved through the use of a U-shaped magnet core giving a minimum air gap with the contactor closed and by the use of "shading coils" which produce a small out of phase flux sufficient to retain the contactor closed while the main flux passes through zero. The tendency to chatter could be overcome through use of multiphase magnet coils on the contactors but the additional complication is undesirable and single phase coils are commonly used.

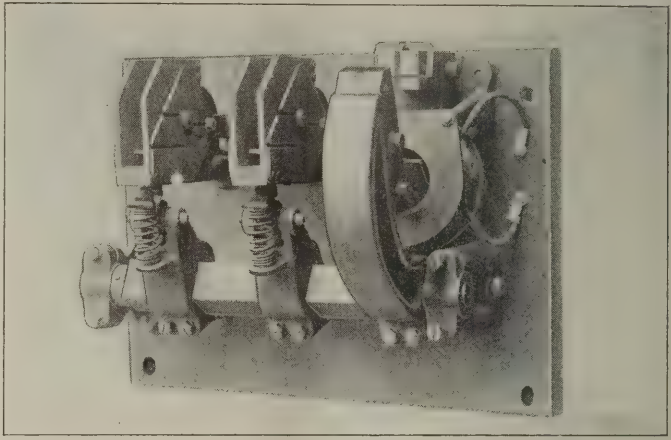


Fig. 2—Two Pole Alternating Current Contactor Unit

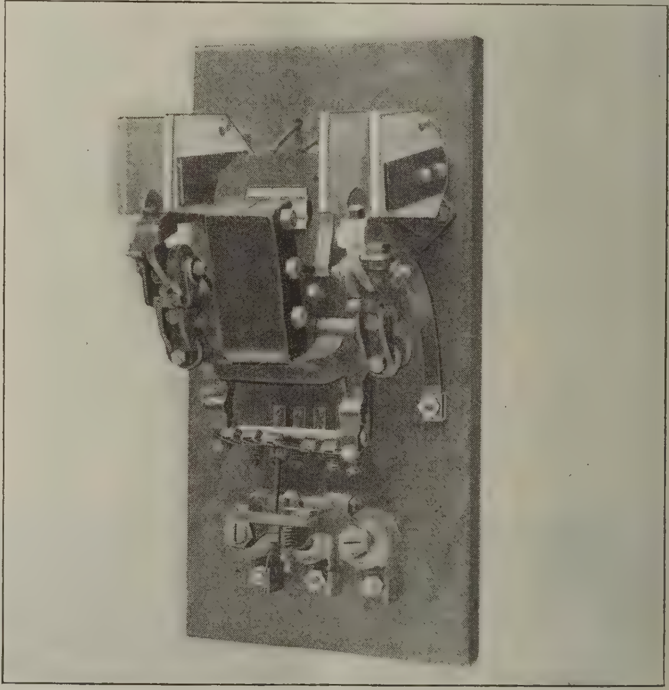


Fig. 3—Two Pole A. C. Contactor Unit With Three Phase Accelerating Relay

Since the control of alternating current motors involves the simultaneous opening or closing of contacts in the different phases, alternating current contactors are commonly multipole. Two pole contactors are the more common but three and four pole contactors are entirely practical. Fig. 1 shows a two pole contactor unit suitable for voltages up to 600 volts. The unit comprises a rather powerful magnet with liberal lever arm and an insulated shaft carrying the two contact units. Fig. 2 shows a similar unit by a different manufacturer. Fig. 3 shows a third type. In this unit the two contacts are located on either side of the magnet.

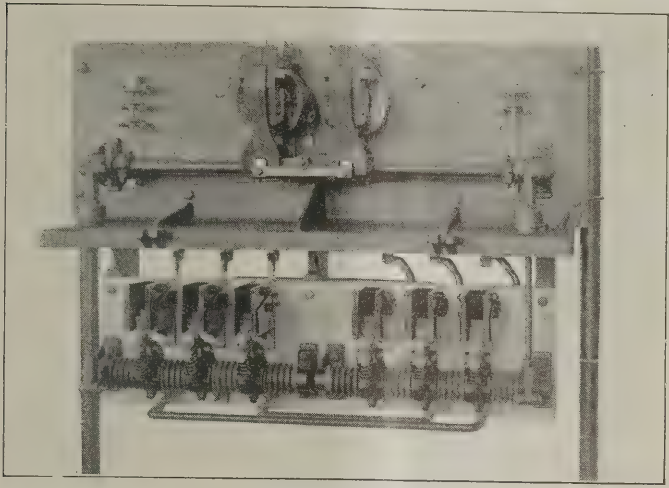


Fig. 4—Oil Immersed Magnetic Contactors for High Voltage Alternating Current Service—Oil Tank Not Shown

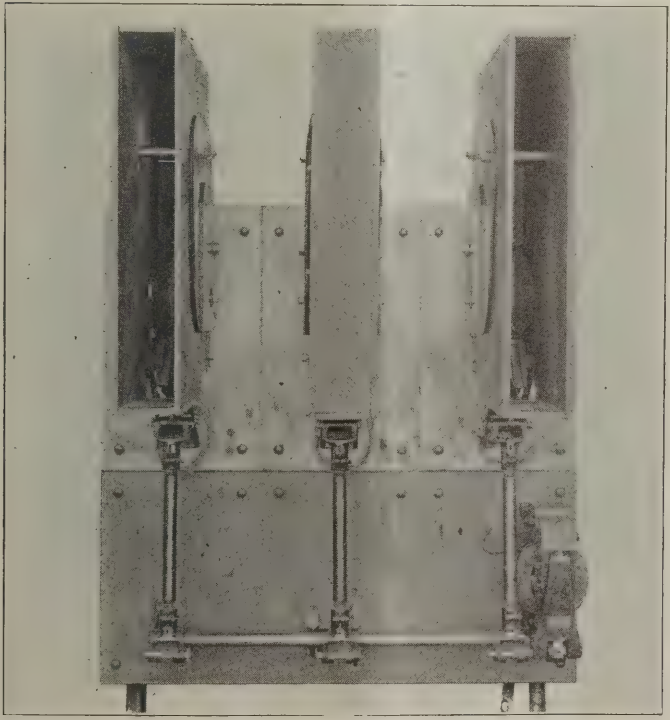


Fig. 5—Air Brake Magnetic Contactors for High Voltage Alternating Current Service

Contactors of the type just described are suitable for use on circuits of low voltage and find extensive use upon magnetic controllers for motors up to 600 volts. For higher voltage control oil immersed contactors are more commonly employed. Fig. 4 shows a three pole oil immersed reversing contactor equipment for 2,300 volt duty.

Oil immersed contactors are suitable and satisfactory for the many applications which involve only occasional starting and stopping. When the service is more frequent, as in mine hoist duty, the oil immersed contactor is not suited because of rapid carbonization of the oil. For frequent duty the high voltage air break contactor is best adapted. Fig. 5 shows a three pole contactor unit of this type. The liberal clearances and large arc shields are particularly noticeable.

It is to be noted that neither oil immersed nor air break contactors of the high voltage type have sufficient rupturing capacity to serve as circuit breakers. They will handle safely the loads incident to normal operation. To protect against overloads and short circuits it is advisable to install, ahead of the magnetic controller, a suitable oil switch, the overload trip devices acting upon the oil switch. On the other hand, low voltage contactor units are commonly employed in conjunction with overload trip devices.

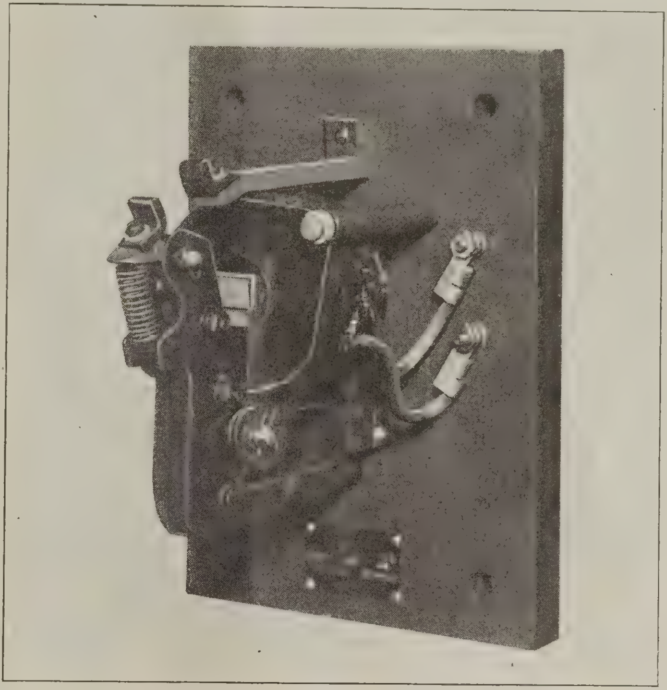


Fig. 6—Alternating Current Voltage Relay

Relays play an important part in the make up of alternating current controllers. The more common types are voltage relays, overload relays and accelerating relays operating on the time element and current limit principles. Fig. 6 shows a voltage relay which is merely a small shunt wound single phase alternating current contactor of the clapper type. This contactor carries control circuits only. It is more commonly employed to provide a no voltage protection feature.

Fig. 7 shows two voltage relays which are so arranged that should one line of a polyphase circuit be opened, while a motor is in operation, the motor will continue to operate single phase until stopped. It then prevents further operation of the controller until the fault is corrected. The connections for use on a three phase system are shown in Fig. 8. It will be noted that relay No. 2 is connected across lines *x-y*. If the feed to either of these lines is opened the potential upon them will be retained by regenerative action of the motor. When the motor stops voltage generated by the motor ceases. The relay then remains open and prevents operation of the control until the fault is corrected. Protection against phase reversal is obtained through the use of relay *A*. The coil of this relay is energized by current taken from two circuits namely, from line *x* through resistance and from line *y* through reactance. With phases normally connected these two currents are approximately in phase so that the resultant current is sufficient to retain the relay closed. Should one phase be reversed the two component currents are thrown out of phase to such an extent that their resultant is insufficient to retain the relay. Relay *A* also supplements relay *B* in giving protection in case of voltage failure on line *z*.

An alternating current overload relay of the instantaneous trip, magnetic reset type is shown in Fig. 9. An overload relay having an inverse time element trip feature is shown in Fig. 10. The time element is obtained through use of an oil dash pot. The use of time element overload relays is common in connection with the control of induction motors. These relays are adjusted not to trip under the momentary starting inrushes but to protect against sustained overloads. It is the common practice to install two overload relays in two of the lines feeding a polyphase induction motor. Protection is thus secured against overloading in any phase. A measure of protection is also afforded against single phase operation, resulting in overloading one phase. In this connection it may be noted that the primary or line contactor which is tripped by the overload relays, is a multipole contactor and opens both phases of a two phase circuit and either two or three lines in a three phase circuit, thereby avoiding any possibility of single phase operation.

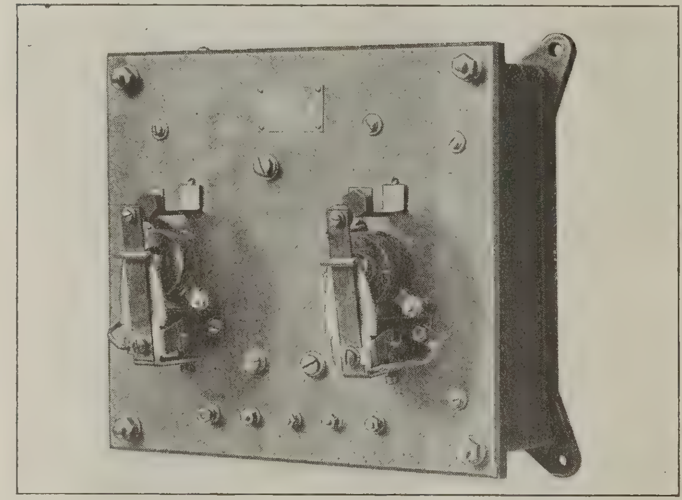


Fig. 7—Reverse Phase and Phase Failure Relay Combination

An overload relay of the induction type is shown in Fig. 11. This relay secures its time element through rotation of a copper disc between permanent magnets, supplying a retarding force. It has an inverse time characteristic. Its action may be predetermined with greater accuracy than is possible with relays of air or oil dash pot types. The use of this type of relay is largely confined to the larger motors because of its relatively higher cost.

For the acceleration of induction motors by magnetic controllers, relays of either time element or current limit types find extensive use. Fig. 12 shows a time element accelerating relay for an alternating current controller. The relay coil is energized ordinarily through a pilot circuit from the master controller. The time element feature is obtained by means of an air dash pot which has a needle valve adjustment.

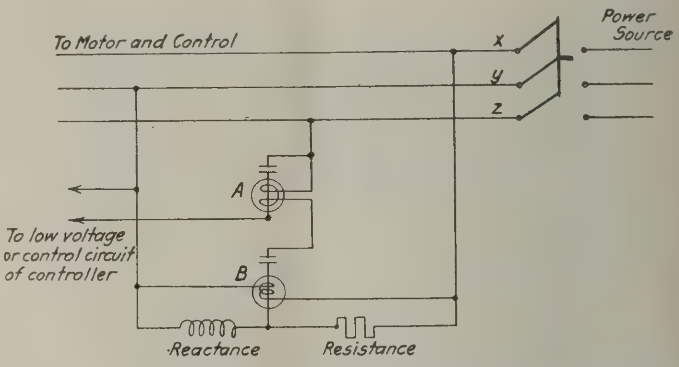


Fig. 8—Diagram of Reverse Phase and Phase Failure Protective Panel

Accelerating relays of the current limit type must be connected of necessity, in the primary circuit of squirrel cage induction motors. In the case of wound rotor motors the accelerating relay or relays may be connected in either the primary or the secondary circuit. Fig. 13 shows a current limit relay, the current coil of which is connected in the primary circuit for the control of either a squirrel cage or wound rotor motor. This relay has also a shunt coil which is connected in series with an accelerating contactor. When the shunt coil is energized its armature is attracted. This releases the armature of the current relay permitting it to drop when the current has fallen to the prescribed value.

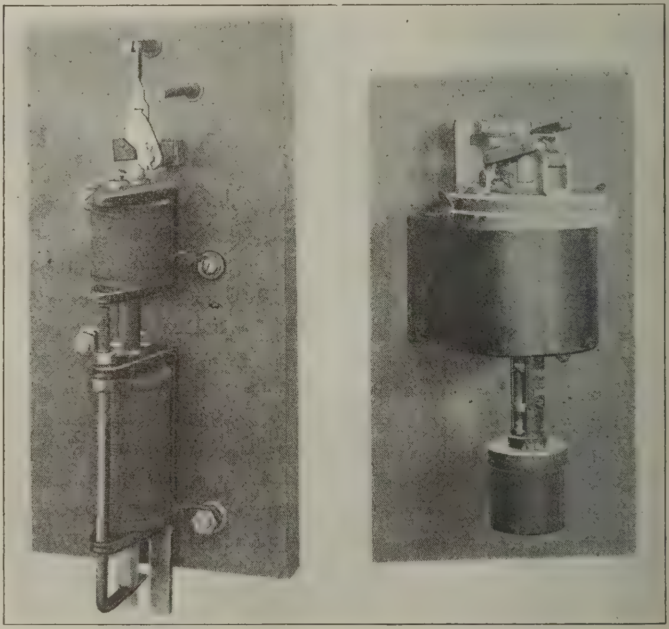


Fig. 9 Fig. 10

Fig. 9—Alternating Current Overload Relay
Fig. 10—Time Limit Overload Relay

This relay closes contacts which short circuit the shunt coil of the relay and thus cause the closing coil of the accelerating contactor to be fully energized, closing same.

The relay above described is electrically interlocked with the controller through the medium of the shunt coil. A current limit relay mechanically interlocked with a contactor is shown in Fig. 2. When the contactor is open the relay cannot close. When the contactor closes the relay armature is held open by the current in the series coil until that current falls to a prescribed value. The relay armature then drops, closing a control circuit to permit further acceleration of the motor. On a magnetic controller of a squirrel cage motor the relay coil is connected in the primary circuit. On a controller for a wound rotor motor the relay coil is connected in the secondary circuit. This arrangement has the advantage of simpler connections. It has some advantage in that motors of differing primary voltages usually have identical secondaries, so that a lesser variety of relay coils covers a wide range of motors. It is to be noted that the frequency in the secondary circuit of a wound rotor motor varies and becomes low as the motor approaches synchronism. A relay of this type requires careful design to avoid chattering as the current passes through zero at low frequencies.

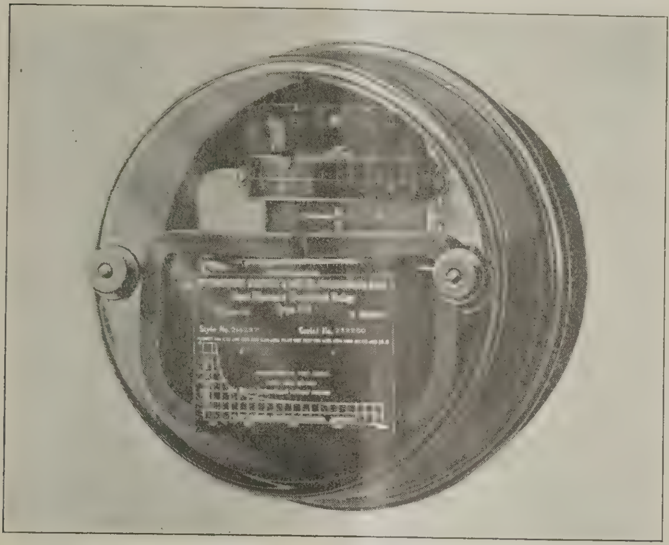


Fig. 11—Induction Type Overload Relay

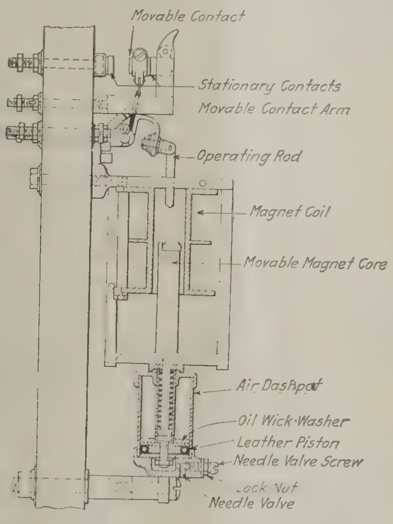


Fig. 12—Sectional View of Time Limit Accelerating Relay

To avoid the last named difficulty a three phase current limit relay, connected in the secondary circuit, is employed by one manufacturer. This is shown mechanically interlocked with a contactor, in Fig. 3. The three coils are connected in the three secondary lines, usually forming the wye. As the currents in the three coils are out of phase the pull of this relay is constant. It therefore has no tendency to chatter and permits of relatively accurate calibration.

The relay shown in Fig. 14 is a step back or jamming relay. It carries a series coil which is connected in the secondary circuit of a wound rotor motor. Its function is to open a circuit when the current exceeds a set value, causing resistance to be cut into the secondary circuit of the motor. This relay has separate adjustments to determine the current values at which it will pick up and drop, respectively closing and opening the control circuit governed.

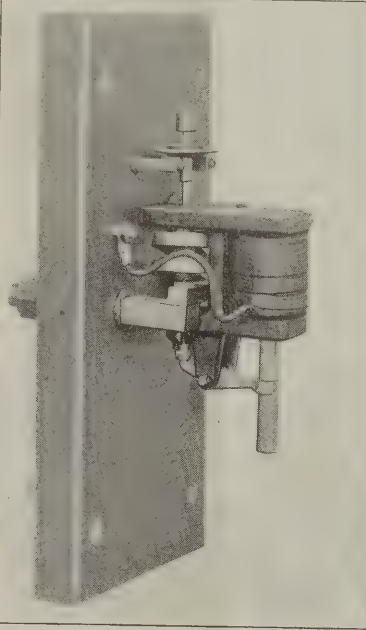


Fig. 13

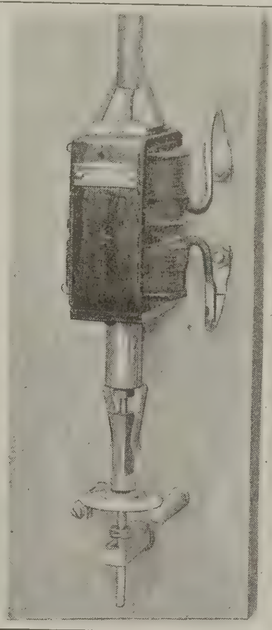


Fig. 14

Fig. 13—Relay Used With Alternating Current Contactor Control Equipments for Obtaining Automatic Current Limit Acceleration of the Motor

Fig. 14—Notching Down Relay

The anthracite mines of Pennsylvania were idle on Mitchell Day, October 29; All Saints Day, November 1, and Election Day, November 2, and the amount of coal lost by this suspension of work, according to preliminary figures based on returns from 15 leading producers, and calculated on the regular daily averages of production, was 714,128 tons, including probably 540,409 tons of household coal, or sufficient to have cared for a city of more than 200,000 inhabitants for a year. New York, Washington and other cities have complained that they have not received to date as much anthracite as was received to corresponding dates in former years. The amount of production lost would have made up the entire reported shortage in New York and Washington.

The Dry Cell—Its Use and Abuse*

By J. M. Spangler

In 1888 Dr. Cassner of Berlin produced a dry cell which resembles the one in use today. About the same time William Burnley of Painesville, Ohio, developed the first really successful commercial dry cell. His cell consisted of a zinc can serving as an anode and also as a container for a carbon rod surrounded by a depolarizing mixture, and an electrolyte in the form of a jelly. Since Mr. Burnley's efforts formed the nucleus of a great industry, it is interesting to observe some of his personal experiences.

After he had secured patents covering his invention, he licensed several companies in the United States to manufacture and market cells under his patents. Due to his inexperience in business matters he failed to realize the remuneration due him to any great extent. He then licensed individuals in England to produce dry cells under his patents and again, through lack of foresight and experience, he failed to receive returns. Next he attempted to manufacture dry cells in a small way, but without much success.

The Dry Cell of Today

A dry cell is portable and its electrolyte is contained in an absorbent material which permits the cell being used in any position. All of the chemical reactions in a dry cell are not exactly understood. However, the following is a brief discussion of the principal chemical changes that take place and which are typical for cells of this type.

Zinc is used as an anode; a solution of ammonium chloride, which is commercial sal-ammoniac, is the electrolyte and a mixture of carbon and manganese dioxide is the cathode. When the zinc is in contact with the solution of ammonium chloride it becomes negatively charged because of the departure of positive zinc from its surface. As zinc dissolves in the electrolyte, zinc, ammonia and hydrogen are produced. The carbon-manganese-dioxide electrode in contact with the solution of ammonium chloride becomes positively charged. The manganese dioxide diminishes the polarization of the cell, and is at the same time reduced to a lower state of oxidation. If the positively charged electrode (carbon-manganese-dioxide) is connected to the zinc (the negatively charged electrode) by a wire, a current will flow through the wire from the carbon to the zinc; within the cell a current will flow from the zinc through the electrolyte to the carbon manganese dioxide. Ordinarily the zinc serves as the container for the cell. The electrolyte consists of a water solution of ammonium chloride, zinc chloride, and other compounds characteristic of different types of cells. It is held partly in an absorbent material that lines the zinc container, and partly in the mixture of the ground carbon and manganese dioxide. This latter is bulky and occupies most of the interior of the cell. Between the zinc and the depolarizing mixture there must be a lining or a partition which will prevent direct electrical conduction.

When the cell is new the surface of the composite carbon-manganese-dioxide electrode may be considered to be the outside surface of this mixture next to the zinc, but as the cell is discharged, the manganese dioxide is reduced, and the effective surface of the electrode travels toward the carbon rod, which is in the center of the cell. This carbon rod also serves to conduct the current out of the mixture to the terminal post.

How the Zinc Cans Are Made

The zinc used in the dry cells is rolled into sheets and cut to size before it is obtained by the dry cell manufacturers, after which it is formed into cans by regular can-making machinery. For electro-chemical reasons zinc of a high degree of purity is desirable, but it is also important for the metal to have high tensile strength and elongation because the carbon-manganese-dioxide mixture is tamped into the can by machinery and the can must be strong to prevent deformation or splitting.

Other Features in the Process of Manufacture

The carbon rod may be considered as a collector of current from the carbon-manganese-dioxide mixture. In many cases the carbon rods are corrugated, thereby giving a larger surface than the cylindrical form. However, the greatest advantage of the corrugated rods is that they are less liable to become loose.

The electrodes are insulated from each other at the top of the cell by a layer of sealing compound. This compound should make good mechanical contact with the zinc can and the carbon rod, but it is not desirable to seal the cell hermetically as gases must escape during the operation of the cell. The compound should not flow in hot weather and should not become excessively brittle in cold weather.

Before the cell is filled with the depolarizing mixture, a lining of pulp board is placed in the zinc can. This serves as an absorbent for the electrolyte and separates the manganese dioxide mixture from the zinc. After the mixture has been tamped into the cell around the carbon rod, the pulp board lining is folded down over the top.

Three General Types of Dry Cells

By changing the mixtures, characteristics can be secured which are highly desirable for some services and therefore dry cells may be divided into three general types, "light drain" for telephone work, general purpose cells and "heavy duty" for ignition work. The telephone cells are intended for light intermittent service such as door bell ringing, telephones and similar work. They are better suited for this purpose than the general purpose battery or the ignition service cells. The voltage is the same as for the ignition cells, but the short circuit current is considerably less, it being slightly over 20 amperes on the average, and sometimes as low as 15 or 16 amperes. This cell has a comparatively high internal resistance and particular attention is paid to its shelf life properties, for the reason that very often on light drain work shelf life is more of a determining factor than the uses to which the cell is put.

The general purpose cell has a slightly lower internal resistance than the telephone cell, but has some of the characteristics of the ignition cell, inasmuch as its short circuit amperage usually averages 24 or 25 amperes and may be used successfully on telephone or ignition work. On telephone work it will not last as long as the regular telephone battery, and on ignition work it will not last as long as the special ignition cell. However, it gives satisfactory service for both kinds of work, and may be of advantage to the user who does not desire to carry several kinds of cells in stock.

---

*Abstract of paper presented at meeting of St. Paul Section Committee, Signal Division, A. R. A., on September 18, 1920.

The ignition cell has a low internal resistance and a high short circuit amperage, usually around 25 to 30 amperes. It is built for heavy duty service and has a great recuperative power; naturally this cell must have good depolarizing properties. Any service that would exhaust a dry cell in six or seven months might be considered as similar to ignition service. Ignition service, perhaps, is a misnomer, inasmuch as there are many conditions in telephone train dispatching, etc., where the service is just as hard as in ignition work. Therefore, under such conditions, ignition batteries should be used.

Temperature and Service Conditions

Dry cells are somewhat affected by changes in temperature. The effect on voltage, however, is very small, but is more noticeable on the short circuit amperage. Excessive heat is detrimental; it tends to produce leakage, causing the electrolyte to ooze out around the seal of the cell, and it increases the rate of chemical reaction within the cell. At the end of a three-month period dry cells that have been subjected continuously to 77 degrees F. show aproximately 10 per cent decrease in short circuit current, while those subjected to 95 degrees F. show a percentage decrease of 19 per cent. Cells which are subjected to low temperatures may even be frozen, but when thawed out bcome normal again.

Service tests show that where dry cells are used on a *continuous discharge* the high duty or ignition cells would give better results under higher temperature, such as 100 to 120 degrees F., while for the low rates of discharge, on *continuous service,* lower temperatures, such as from 30 to 40 degrees F., are desirable.

It is difficult to estimate the ampere hour capacity of a dry cell in a manner similar to a storage battery or a soda cell, since the discharge rates and the point at which the voltage value is deemed too low for successful operation are so variable. However, as a general statement, it is safe to say that the average 6 in. dry cell will deliver 20 ampere hours.

A highly desirable feature of any dry cell is uniformity of performance. This is governed greatly by the purity of the materials and the methods of applying them in the cell. It can be seen how impurities in the zinc or in the electrolyte could cause local action, corrosion, etc., thus shortening the life and giving detrimental results. But possibly the process that governs uniformity more than any other single factor is the method of tamping the mix around the carbon post in the zinc can. The old-fashioned method was to sprinkle a little mix into the can around the electrode and tamp it down with a mallet and a mold; then add a little more mix and tamp again. The general result was a non-uniform product.

Testing of Dry Cells

The simplest test, the one usually made by the layman, is the short circuit current test. The user, too often, estimates the service life from such a test, when, as a matter of fact, this value is no criterion of the service to be received. All short circuit current tests should be taken with very short leads on the meter. For example, if a dry cell built for ignition purposes gives a short circuit reading of from 27 to 30 amperes, it is in good condition; while a dry cell built for telephone service or a light current drain will only give a short circuit current reading from 15 to 18 amperes, and it will be in good condition for the service for which it is intended. The user too often confuses the low drain cell with the ignition cell, and thinks that any cell with a short circuit current reading of 15 amperes, has lost the greater portion of its service life. If at all possible, short circuit current tests should be made while the dry cell is at a temperature of about 70 degrees. The value of the short circuit current in this test is an indication of the condition of the cell as compared with the normal value of the cell of the same manufacture and brand. Some cells are manufactured expressly for a high short circuit amperage, some even giving as high as 40 or 45 amperes, but this is no criterion that they are worth more for the service intended than are cells of 27 to 30 amperes, or a telephone cell of, say, 16 amperes. Dry cells are built for certain specific services, but to give the best results they should be used for the services for which they are designed.

Another test is known as the intermittent telephone test, or, as modified by the American Telephone & Telegraph Company, is known as the A. T. & T. test, which is about as follows: Three cells connected in series are discharged through 20 ohms for 10 periods of 4 min. each, in 10 consecutive hr. of 6 days per week. On the seventh day every other period is omitted. The end of the test is taken as 2.8 volts for the battery on closed circuit. The results are then expressed as the number of days the test lasted.

The ignition test is conducted by connecting 6 cells in series to a circuit of 16 ohms. These cells are discharged for 1 hr. in the morning and 1 hr. in the afternoon each day until the impulse current has fallen to 4 amperes. This impulse current is the current that is discharged through ½ ohm at the end of a period of discharge through the 16 ohms.

One very important test is the shelf life test. This consists of placing the cells in storage in an even temperature if that is possible, and at certain regular intervals the short circuit amperage is read, and also the open circuit voltage. The results then are reckoned as the per cent drop in amperage for certain specified periods of time. This is a very important test, and especially so for telephone users, where the factor of shelf life is one to be considered.

Abuse of Dry Cells

Dry cells receive considerable abuse and it is very important that such abuses be corrected by calling them to the attention of the users who are not familiar with the cells. With the advent of the motor car on railroads dry cells became more generally used by men who were not at all familiar with electrical characteristics. Lack of knowledge and experience is the reason for short circuits, electrical connections made wrong, dry cells stored in wet places, and carried promiscuously in a bag in a jumbled manner which permits the carbon and zinc posts to come in contact with each other and short circuit the cells. Railroad men, especially in the maintenance of way department, should be instructed how to treat the dry cells to secure the best results.

Storekeepers should be very careful to rotate their stock; that is, always hand out the oldest dry cells first. When a new shipment comes in it should not be placed on the shelves in front of the dry cells in stock, but the old ones should be placed in front of the new ones, so that they will be used first.

Dry cells should always be stood on end when being stored and placed in a cool, dry location. Even though a dry cell stands a great deal of rough handling, a barrel containing them should not be handled unnecessarily rough for the reason that the mix has a tendency to become loosened from the carbon posts, and this increases the internal resistance of the cell.

When connecting dry cells together it is not necessary to use a Stillson wrench. If dry cells are treated in a reasonable manner they will give more than reasonable results.

Wireless in Railroad Service

The Louisville & Nashville and the Nashville, Chattanooga & St. Louis have been carrying on exhaustive experiments in radio telegraph and telephone work under the direction of R. R. Hobbs, superintendent of telegraph of these two roads. These experiments are not being made to test the practicability of radio service in general, as that fact has long since been demonstrated, but to determine its adaptability to the everyday necessities of the railroads. At the present time no tests are being made on train installations, but long and short wave apparatus is being tried out carefully and thoroughly in actual service and under varying weather, climatic and topographical conditions. The railroad is proceeding cautiously, and while the tests have not yet been completed, developments so far have been highly satisfactory.

The Louisville & Nashville has two stations in the general office at Louisville, one being located in the automatic telephone room on the twelfth floor and the other in the private office of the superintendent of telegraph on the ninth floor. These sets are of radically different types. The twelfth floor is a de Forest series honeycomb coil arrangement with audion detector and two-step audion amplifier, for strictly long wave reception. This set is mounted in a carefully selected position where inductive disturbances are the maximum, day and night; it is close to a main frame where 500 telephone and telegraph circuits center, many of the telephone circuits being arranged for phantom auxiliary and carrying over the same pair of wires telegraph duplex, printing-telegraph and composite; in other words, all of the modern methods of wire utilization to the fullest extent. In installing these sets, the railroad wanted to discount at once all of the inductive and static troubles it could expect on the line, and all known tests were tried out with more or less success with the result that the set remains in the same location and is receiving signals clearly and distinctly from overseas stations with a minimum of interference. The apparatus in the office of the superintendent of telegraph consists of a short wave regenerative receiving set coupled to a three-step audion amplifier cabinet equipped with audion detector and grid condenser. The short wave cabinet has two variometers, a coupler, and secondary tuner. Switches are so arranged that the short wave section can be cut off and the audion amplifiers and detector transformed to long wave reception, throwing in through the tickler a primary and secondary de Forest honeycomb coil arrangement, which coils are equipped with variable condensers for positive tuning. A sending set of small capacity is also attached for testing purposes only. On this set practically all of the ship and land stations overseas can be copied with ease.

The aerial question has been taken care of in several different ways. Early in the experiments the railroad learned that experts differed greatly as to antenna construction and that there were no set rules or specifications governing all conditions. An aerial that would receive and send perfectly in one location was useless in another; one aerial would pick up static and another would not, but likewise would not absorb the sending energy from another station. In one locality static disturbance was at its maximum during a hot day, while the same aerial erected at another point would not pick up this static. The railroad built all types for experiment, with switches to throw them into sets. It now has six different aerials at Louisville, these being known in wireless technology as "inverted L," "T," "Fan,," "Loop," "Single" and "V." They were not expensive and a total of less than two miles of copper wire was used. They are all good, but of different wave lengths and efficiency; some develop more static than others, but the signals ride in over and above this disturbance.

After several months' experiment it was decided to put in two stations on the N. C. & St. L., these stations being located at Tullahoma, Tenn., and Guntersville, Ala., the installations to be made during September. Between these two points it has been impracticable to establish land telephone or telegraph service because of waterways. The airline distance is 70 miles. The equipment will be of the short wave regenerative type with sending energy of 1 kw. These stations will be followed by others, and it is expected that in the near future all division headquarters on the two railroads will be linked to the general offices by radio, as an auxiliary to the land lines.

The Louisville & Nashville is particularly anxious to establish radio service between Louisville, Mobile and New Orleans because of the severe storms that occur in the New Orleans district every few years, when it is almost impossible to maintain wire service. It appears from the present experiments that it will be entirely practicable to do so, as signals are now being received from radio stations at the points mentioned, very clearly and distinctly.

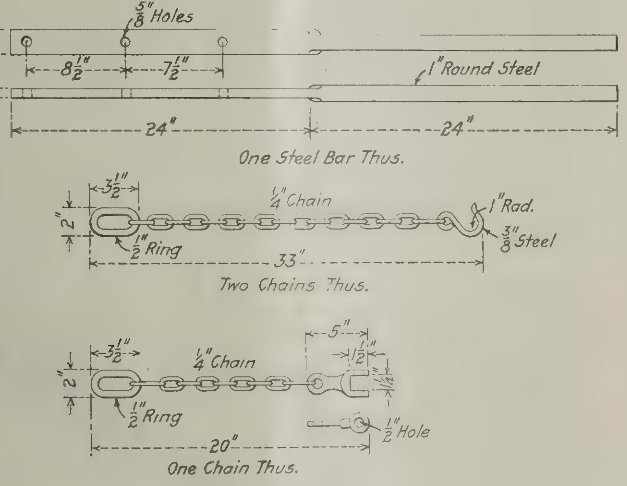
The fifteenth international conference of the Railroad Young Men's Christian Associations of North America will be held in Richmond, Va., November 18-21, 1920. It has been the custom to hold these conferences at three-year intervals, but the world war interfered with this arrangement and this will be the first conference for a number of years. It is expected that about 1,200 railroad men will be present, representing every section of the country and every department of railroad service. The program is being prepared under the direction of Dr. John P. Munn, chairman of the Transportation Committee of the International Committee of the Y. M. C. A., and E. L. Hamilton, senior transportation department secretary.

PRACTICAL STUNTS

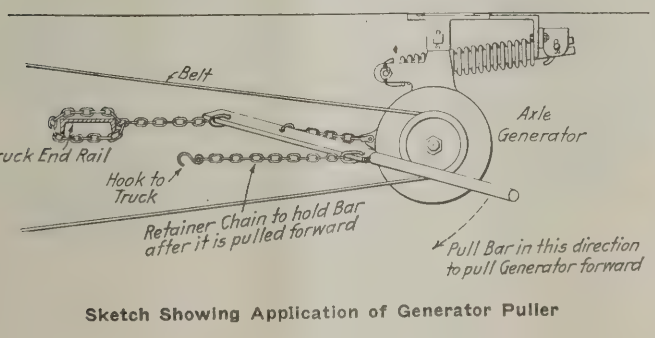
Another Type of Generator Puller

In the Practical Stunts' column of the *Railway Electric Engineer* for September there appeared an article describing and illustrating a method by which axle generator belts might be readily applied and removed. The device described was one constructed upon the turnbuckle principle. That other types have been found successful is indicated from the following description:

Another type of generator puller which has been found exceedingly useful and which may be easily and quickly applied, is shown in detail and application in the two sketches. When an axle generator belt is found to be missing within a few minutes of train time, there is no time to be spared. If the generator is a truck suspended one, it can be easily pried forward with a bar and a new belt applied. Suppose, however, the generator is not a truck suspended one, but, instead, it is a body-hung machine. In this latter case a train detention is apt to result, unless some device is at hand which can be easily applied to pull the generator forward and quickly put on a new belt.



Construction Details of Bar and Chains


Belt
Axle Generator
Truck End Rail
Hook to Truck
Retainer Chain to hold Bar after it is pulled forward
Pull Bar in this direction to pull Generator forward

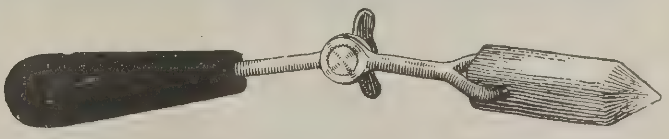
Sketch Showing Application of Generator Puller

Various types and makes of generators are now suspended from the car body, therefore the device must be one which can be used universally. An arrangement of this type which recommends itself by its simplicity, consists of a bar and three chains. One of these chains is attached to the truck end rail and a second chain to the generator. The bar is then moved forward as shown by the dotted line, which movement pulls the generator forward. The third or remaining chain comes into play when the generator has been pulled forward. This chain serves to hold the machine forward while the belt is being applied.

This device is a great time and labor saver and may be used on any type of body-hung generator. When equipped with this outfit one man can apply or remove a generator belt with ease so that a car detention due to a missing belt is a rare occurrence.

A Handy Soldering Iron

Occasionally, electricians and others who are called upon to do soldering, find the task somewhat difficult with a straight-handled soldering iron when the work is hard to get at. In a recent issue of *Power* a semi-flexible soldering iron was described, which permits soldering to be done in hard-to-get-at places and at the same time adjustment can be made to provide a straight-handled tool for ordinary work. The illustration shows the arrangement and method of adjustment. This adjustable feature can be applied to the ordinary soldering iron by cutting the rod which projects from the iron into the handle in two, and welding an eye to each piece. A short counter-sunk bolt with wing nut provides a ready means of tightening up the adjustment at any desirable angle.



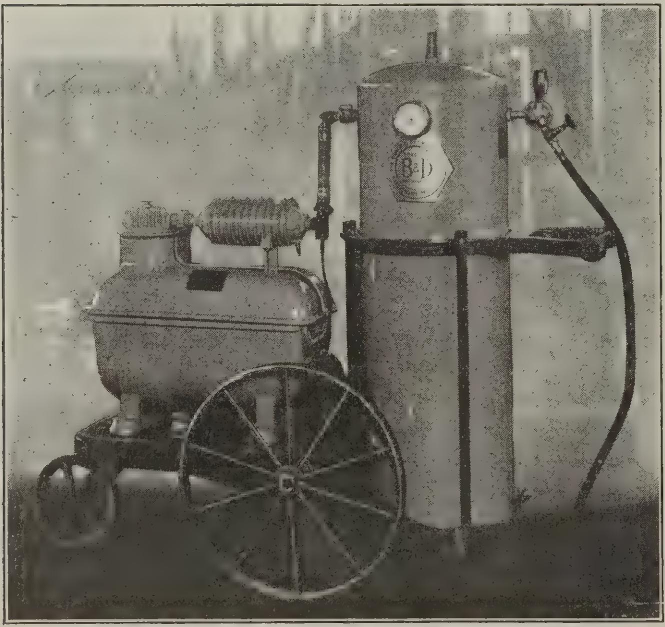
The Adjustable Soldering Iron

NEW DEVICES

Machinery Blowing Outfit

The portable electric air compressor and tank, shown in the illustration, has been developed by the Black & Decker Manufacturing Company, Towson Heights, Baltimore, Md. It is designed primarily for blowing out motors and generators and for cleaning engines and shop machines where other sources of compressed air are not available. It can also be used for inflating tires.

The machine consists of an air compressor driven by an electric motor and a 40-gallon air reservoir mounted on a three wheel carriage provided with pushing handle and brake. An automatic switch keeps the pressure in the tank between 160 and 200 lb. and an automatic unloader keeps the load off the compressor when the motor is starting. The blow gun furnished with the outfit has a jet about 1/16 in. in diameter. Three and one half minutes are required to bring air pressure in the tank from 160 lb. to 200 lb., sixteen minutes to charge the tank from 0 to 200 lb. pressure and the compressor will maintain pressure in the tank at something over 60 lb. with the blow gun operating continuously.



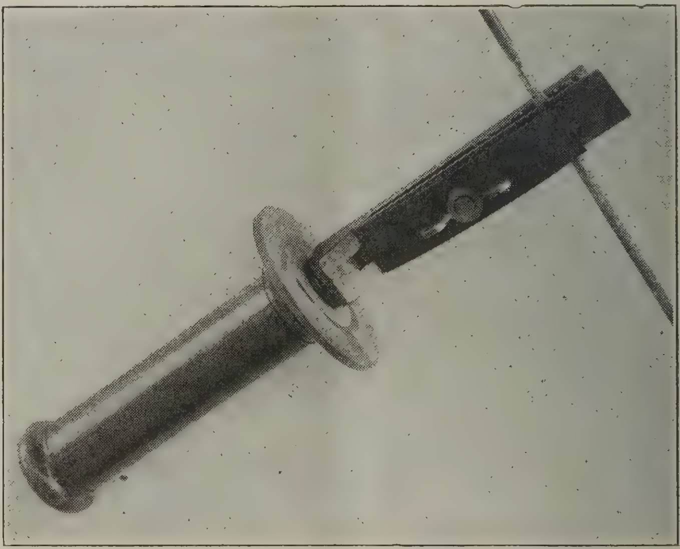
Portable Electric Air Compressor and Tank

The air compressor is all enclosed, air cooled and grease lubricated, has a guaranteed volumetric capacity of 6 cu. ft. of free air per minute and a guaranteed pressure capacity of 200 lb.

Electrode Holder

A new arc welding electrode holder is offered by the Transportation Engineering Corporation, New York. The special features are its simplicity and the provision made for easily replacing the parts damaged by use. It is also designed so that there are no projecting parts to be burnt off and damaged in service.

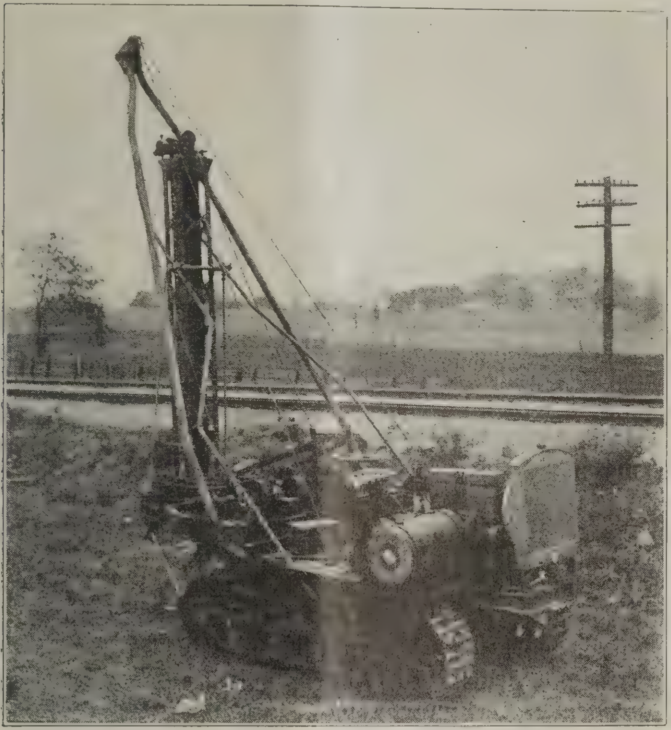
The holder consists of a copper casting provided with a leaf spring clip, the tension on which is adjusted by a brass wing nut. Spring adjustment is only made when changing from one size electrode to another. The holder is also provided with a wooden handle and a fiber disc shield. The copper casting is grooved at the end to hold the electrode rigid at two angles. If desired the holder is furnished with five feet of special extra flexible welding cable. To use the holder, the electrode is forced between the copper jaw and the spring clip. Then, when that electrode is burnt down, a new one is inserted and given a slight twist which pries the clip away from the copper jaw allowing the stub end to drop out. This operation is repeated as each electrode is used up.



"Tecor" Welding Electrode Holder

Hole Boring and Pole Setting Machine

A machine for boring holes has been developed and placed on the market recently by the International Earth Boring Machine Corporation, Chicago. This equipment bores holes from 6 in. in diameter to 30 in. in diameter, 8 or more feet in depth, and is arranged with appliances for setting the poles in the holes after they are bored. While this machine primarily has been designed for the above mentioned purpose it can also be used to advantage for foundation work and similar construction. Under favorable working conditions it is claimed that it is possible with this machine to bore 100 holes and set 100 poles per day; that construction gangs using this machine have been able to bore holes in 45 sec., and that holes 2 ft. in diameter by 8 ft. deep have been bored through hard pan in 12½ min. Formerly holes of this character had to be blasted. The claim is made that the saving per hole by the use of this machine is such that the machine will soon pay for itself. The machine has demonstrated its adaptability and capacity for drilling through frozen ground, hard pan, shale, daube, gumbo, red, gray and blue clay, ordinary soil, gravel, sand, loose brick and loose concrete.



Type C Crawler Tractor Equipment

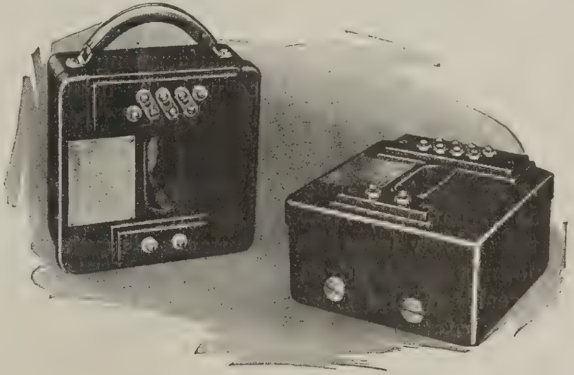
Type B Machine Boring Anchor Holes

Machines for this purpose are built in three types, as follows: Type A is horse drawn, with the boring machine and derrick mounted on a turnable arranged on a wagon frame. Power is furnished by a gasoline motor on the turntable. Type B is a four-wheel-drive motor truck with the boring mechanism and derrick mounted on a turntable clamped to the motor truck frame. Power for the boring mechanism and winch is furnished direct from the truck engine. It is claimed that this machine has great maneuvering capacities. Type C is called the "crawler-tractor." Its boring mechanism and derrick are mounted on a frame of the machine and the power for the boring mechanism and winch is supplied through a special gearing from the tractor engine. This machine can travel and operate on swampy ground or steep railroad embankments.

Portable Current Transformers with Six Primary Ranges

The Esterline Company, Indianapolis, Ind., has developed a portable current transformer called a "Universal" type, which has a secondary current rating of 5 amperes and 6 primary ranges, namely: 25, 50, 100, 200, 400 and 800 amperes. The first three ranges are obtained by simple series-parallel connections on a convenient terminal block, and the higher ranges by a "through" type primary winding.

The reason for the development of this kind of current transformer is that heretofore the current transformers available have had only 3 ranges in a single transformer, so that a number of sets of current transformers were necessary to impart to an instrument the range of capacity commonly used. This resulted in the complete equipment being unnecessarily expensive and somewhat heavy. A metal containing case is provided made of cast aluminum, designed to protect the transformer from the effects of heat, moisture and rough handling.



Two Views of Six-Range Portable Transformer

The new transformer is intended for use with graphic, as well as indicating meters and has a continuous overload capacity of 150 percent normal current rating. It has a capacity of 25 volt-amperes and is calibrated to be correct at 15 volt-amperes.

General News Section

The Colorado & Southern is to do away with the telegraph system and adopt telephones for train despatching on its lines from Denver to Fort Worth and from Denver to Cheyenne. The order for the new despatching apparatus has been placed with the **Western Electric Company** and is the largest order this company has received since the railroads were released from federal control. Sixty-five despatching stations will be installed with 493 miles of connecting apparatus.

The Safety Car Heating & Lighting Co. and the Pintsch Compressing Company have removed their general offices to their new plant at Dixwell and Putnam avenues, New Haven, Conn. These offices comprise the sales services department, the purchasing department, the office of the treasurer, and the accounting department, besides the manufacturing and engineering departments. The Northeastern district office will continue at 2 Rector street, New York, but the Jersey City office will be discontinued.

Economy Fuse & Manufacturing Company, Chicago, Ill., announces the appointment of **S. W. Fries** as district sales manager for Kansas City territory, with offices at 1205 Commerce Bldg., Kansas City, Missouri. Mr. Fries succeeds R. P. Crawley, who has resigned the position to take over the active management of the Crawley Electric Company of Peoria, Illinois. Mr. Fries takes his new position with a long and thorough experience and wide acquaintance with the electrical field. He has been with Economy Fuse & Manufacturing Company for a number of years, his service with the house being interrupted only by the time he devoted to patriotic duty in France.

The Ackurate Rubber Company, Inc., with offices at 253 Broadway, New York City, has been incorporated in New Jersey to manufacture insulating tapes, compounds and kindred specialties. **Willard C. Candee,** president, and **Chas. V. Ackerman,** secretary and treasurer of the company, have been identified with this branch of the electrical industry for over twenty years and are putting their entire effort and experience into the production of high quality products only. Their **Ackerman Friction Tape,** now on the market, is put up in paper cartons which are something of a novelty to the trade. They are handling their New York City trade direct and will establish agencies in the principal cities throughout the United States.

At the Port Morris power station of the New York Central in New York City, a 20,000-k.w. turbine and a 35,000-sq. ft. surface condenser will be installed. The General Electric Company has the contract for the installation of the turbine and the Worthington Works, New York City, will supply and install the surface condenser. The estimated cost of this work is approximately $1,000,000. The New York Central has also awarded a contract to the General Electric Company for the installation of a 2,000-kw. rotary converter and three 750-kw. transformers at its Irvington, N. Y., sub-station. The improvement will cost approximately $100,000.

New York University has announced the appointment of **J. W. Dietz** to head a group of executives who will discuss the principles and methods of training employees at its School of Commerce this year. Mr. Dietz is educational director of general commercial departments of the Western Electric Company. The course will take up specific problems of training the office boy, the clerical worker, the skilled shopman, the supervisory force, the salesman and the technical expert.

Mr. Dietz is one of the pioneers in the employee training field, and has been active in educational, industrial and personnel work since 1911, when he was made educational manager at the Western Electric's plant near Chicago, where more than 21,000 people are employed. He has been coordinating the national education and employment problems of his company since January, 1919.

The Superpower System

At a meeting of the New York Electrical Society held on October 7 at 29 West 39th street, New York, William S. Murray, chairman of the Superpower Survey, organized by the United States Government, outlined the progress which has been made by his organization.

The boundaries of the zone have been extended to include a little more of the Northeast Atlantic seaboard and the total area of the zone is now about 60,000 sq. mi., or about 2 per cent of the total area of the country. As originally outlined, the Superpower System would provide an estimated machine capacity of 17,000,000 hp., of which about 10,000,000 would be used for industrial purposes and 7,000,000 for the railroads. The total amount of machine capacity is now estimated to be somewhat in excess of this amount.

With the aid of lantern slides Mr. Murray outlined the advantages which would be gained by such a system. He pointed out that the average steam engine load factor is 10 per cent, that existing central stations have a load factor of about 30 per cent and with such a superpower system a 50 per cent load factor should be possible.

Both steam and water power plants will be used to develop the power required, about 15 per cent of which will be water power. This percentage will shrink as the total power demands grow. The power plants under consideration will develop from 300,000 to 400,000 kilowatts each. The average station now operating in this area has a kilowatt capacity of 3,000 and uses 4.7 lb. of coal per kilowatt hour.

In speaking of the trunk line railroads, which will receive power from this system, Mr. Murray pointed out that electric traction must be warranted by density of traffic and tunnel and terminal conditions. He expressed the opinion that not more than 25 per cent of the steam railroads in this area would be electrified for a long time to come, and that both alternating current and direct current will be used.

New Zealand Railway Electrification

According to an announcement appearing in Engineering, London, H. M. Trade, Commissioner at Wellington, New Zealand, has recently cabled to the Department of Overseas Trade the award of a contract to the English Electric Company for the electrification of a section of the Midland Railway of New Zealand. The section to be electrified is known as "Arthur's Pass." It is the connecting link between the Government railway system of the east coast and west coast of South Island. At present the whole of the railways in New Zealand are steam operated, and it is now proposed to electrify more than the section covered by this contract. The section to be electrified includes a tunnel over 5 miles long and three steel bridges, the rest of the section consisting of earth-works. A great portion of the section is on a grade of 1 to 33 and the summit is about 2,400 ft. above the sea level. Considerable snow falls in some winters, as much as 5 ft. having been experienced. The contract includes the provision of the power plant, the tunnel lighting installation, the overhead transmission line and the complete equipment for the electrical operation of the section of the railway referred to. The system to be used is 1,500 volts direct current overhead contact. The power-house must be at Otira station, which is 1,260 ft. above sea level, and the power will be generated by geared turbine direct-current sets. The boilers, it is proposed, should be operated on dust fuel in order to utilize the product of a number of local coal mines which is too fine for consumption in grates of ordinary construction.

Westinghouse Company Enters the Wireless Field

The Westinghouse Electric & Manufacturing Co. announced recently that it was prepared to enter the wireless field on a large scale. The International Radio Telegraph Company has been taken over by the Westinghouse interests and it is the intention to apply to the manufacture of wireless equipment the benefit of the research and development work undertaken for the government during the war.

The International Radio Telegraph Company maintains wireless stations on ships and has shore stations at Newport, R. I., New London, Conn., Brooklyn, N. Y., and Cape May, N. J., as well as others under construction in Maine and Massachusetts. The company is perfecting a worldwide service of overseas wireless telegraph communication, as well as being active in the development of wireless telephony. R. A. Fessenden, one of the pioneer investigators in the wireless field, founded the company, which controls his patents.

In connection with the new undertaking the Westinghouse company has equipped a special factory at East Springfield, Mass., for the manufacture of wireless apparatus. It will not only furnish outfits for the new International Radio Telegraph Company, but will also devote its energies as well to supplying the needs of watercraft, railroads, power companies, factories, mills, mines, camps and ranches.

The engineers of the company have directed special attention to the problem of reducing interfering electric disturbances, with the result, it is claimed, that the Westinghouse system, as regards reliability, is on a par with the best wire and cable telegraphy.

PERSONALS

Dr. Clayton H. Sharp, technical director of the Electrical Testing Laboratories, New York, has been appointed chairman of the board of examiners of the American Institute of Electrical Engineers, succeeding F. L. Rhodes. Dr. Sharp is a past-president of the Illuminating Engineering Society, of which he was one of the founders, and is co-inventor with Preston S. Miller of several illumination measuring devices, including the Sharp-Miller photometer. Dr. Sharp was graduated from Hamilton College in 1890 and took his doctor's degree at Cornell University. For six years Dr. Sharp engaged in research and instruction work at Cornell, except for an interval of a year spent in European travel and in research in the Physical Institute at Leipsic, Germany.

L. C. Hensel

L. C. Hensell, electrical engineer of the St. Louis-San Francisco, with headquarters at Springfield, Mo., was elected president of the Association of Railway Electrical Engineers at its twelfth annual convention, which was held at the Auditorium Hotel, Chicago, on October 19 to 22, inclusive. Mr. Hensell was born at Port Jervis, N. Y., on December 12, 1878. Six years later his parents moved to Hawley, Pa. He was educated in the high school of that town and completed a course in electrical engineering at Wyoming Seminary at Kingston, Pa. In 1898, he enlisted in Company E, 13th Regiment, Infantry for service in the Spanish-American War. Two years later he was honorably discharged at Camp McKenzie, Augusta, Ga., following which he entered the service of the Lackawanna Steel Company, at Buffalo, N. Y., in the electrical department as foreman of construction. In July, 1903, he resigned to enter the service of the St. Louis-San Francisco at Springfield, Mo., as foreman of construction, electric light and power work. Five years later he became chief electrician, and in 1915 his title was changed to electrical engineer. In August, 1917, he resigned to become assistant superintendent with the Gould Storage Battery Company and while serving in this capacity he had charge of all construction work, including submarine batteries for the United States Government. In April of the following year he returned to the Frisco as electrical engineer, which position he still holds.

Francis V. McGinness, vice-president of the Transportation Engineering Corporation, was elected president of the Railway Supply Manufacturers' Association at the annual convention of that association held at the Auditorium Hotel at Chicago, on October 22. Mr. McGinness graduated from the Columbia University, School of Engineering, with the degree of electrical engineer in 1910, after which for a brief period he was employed in the engineering departments of the New York Telephone Company and the New York & Queens Light & Power Co. In 1911 he became connected with the Edison Storage Battery Company and engaged in experimental work in Mr. Edison's laboratory. While engaged in this capacity he received a thorough training in the manufacture of the Edison battery. Later, he was appointed assistant manager of the railway department of the company, and in March, 1916, he was promoted to manager of the same department, in which capacity he remained until June, 1919, the time at which he became vice-president of the Transportation Engineering Corporation.

F. V. McGinness

Hugh Pattison has joined the staff of the heavy traction railway department of the **Westinghouse Electric & Manufacturing Company** to make special engineering studies under the direction of **F. H. Shepard,** director of heavy traction. Mr. Pattison was graduated from the Johns Hopkins University, electrical engineering course, in 1892. His first position was that of foreman electrician of the Norfolk, Va., Navy Yards, wiring and installing electric apparatus on naval vessels. In 1893, he became assistant engineer with Sprague, Duncan & Hutchinson, consulting engineers at Baltimore. From 1894 to 1903, he was associated as engineering assistant to Frank J. Sprague, vice-president and technical director of the Sprague Electric Company in New York and assisted in equipping and operating multiple unit control on the Boston Elevated and in Brooklyn. In 1905, Mr. Pattison joined Westinghouse, Church, Kerr & Company as an engineer. From 1905 to 1911, during the electrification of the Pennsylvania tunnel into New York, Mr. Pattison was assistant engineer of electric traction for George Gibbs, consulting engineer. Later, Mr. Pattison had charge of the electrification of the West Jersey & Seashore Railroad from Camden to Atlantic City. He also built an experimental single-phase electric railway on the Long Island Railroad and had charge of the conduct of locomotive tests on the West Jersey & Seashore Railroad to determine the effect on track. In 1911, he was appointed engineer in charge of the Chicago Association of Commerce Committee in the study of smoke abatement and the electrification of terminal railways in Chicago. During the war Mr. Pattison was appointed assistant to general manager of the Remington Arms Company.

TRADE PUBLICATIONS

The Copper Clad Steel Company, New York, is distributing three small envelope folders illustrated in color, as well as a 24-page catalogue entitled "Copperweld" wire. The colored folders explain respectively the uses of copper weld wire for low and high voltage power transmission and for railway signal service. The "copperweld" wire catalogue presents a number of tables giving the physical properties of copper weld wire as well as listing and describing the various products into which this wire is made up.

The Black & Decker Mfg. Co., Baltimore, Md., has recently issued a 30-page illustrated pamphlet, illustrating and describing the various types of electric compressors and compressor accessories manufactured by this company. The booklet is 8½ in. by 11 in. in size and contains many full-page photographic reproductions of the company's products. The descriptive matter gives full information relative to the various capacities of the several types of apparatus listed, together with the prices of the different equipments.

The National Metal Molding Company, Pittsburgh, Pa., is distributing a number of illustrated folders showing a number of its products. One of these is devoted to the illustration of National brackets, showing the arrangement of two and three pin brackets for use both on crossarms and on the outside surfaces of buildings. Another folder contains brief descriptions of the company's rigid steel conduit, flexible metal conduit, armored conductors, a flexible non-metallic conduit and the National metal molding.

The Electric Storage Battery Company, Philadelphia, Pa., has recently published a car lighting battery instruction book. The phamphlet, which is 5¼ in. by 8½ in., contains 32 pages, with numerous photographs showing the various parts of the chloride accumulator. The book is especially valuable in that it covers the subject in a most simplified way. A table of contents refers specifically to the various sections of the pamphlet where are described in detail the steps involved in the care and maintenance of the battery from the time it is received. The various steps of battery maintenance are treated in a brief but practical manner.

The Sprague Electric Works of the General Electric, New York, has recently issued its bulletin No. 48961 in which are shown photographic reproductions of the Sprague electric type W hoists. This type of hoist is designed in various capacities from one to six tons and for use on alternating or direct current circuits. The hoist is controlled by an operator on the floor through the medium of connecting cords to the apparatus overhead. Various diagrams and illustrations are given as well as tables showing the capacities and dimensions of the various types of hoists.

Railway Electrical Engineer

Volume 11 December, 1920 Number 12

HOW TO KEEP HIGH WAGES

The current of industrial unrest which was so prevalent a year ago and which manifested itself in countless strikes all over the country has largely subsided and in its place is to be found a better spirit among the workmen in regard to the performance of their duties. In all probability in the majority of instances the change has been brought about by an intelligent interpretation of the handwriting on the wall. Readjustment of all valuations is proceeding rapidly. The numerous applications for work in many industries are not productive of indifference on the part of those already employed. Today the workman will think twice before he cuts himself loose from his job. The very fact that others are seeking his place will greatly enhance its value.

If the railroad employee retains his high scale of wages it will be because he digs in and does his utmost in helping to operate the road more efficiently, for it is becoming more and more evident that the railroads will not be able to meet their expenses, even with the recent increase in rates, unless they are able to secure greater economy in operation. The roads now have no opportunity of drawing upon the government to make up operating deficits. They must be self-supporting and unless each employee gives his whole-hearted effort to the performance of his duties sooner or later he is going to be called upon to show why he, in particular, should enjoy a high wage scale.

A DIFFICULT PERIOD

The slowing down of business during the last few weeks has been reflected in the railway field by a considerable reduction in the number of freight cars loaded per week. It must be remembered, however, that there has always been a reduction in freight traffic during the late fall; the latest records available when this was written indicate that in spite of the heavy falling off in freight car loadings since the peak was reached last October, the number of cars loaded per week still exceeded the figures for corresponding weeks in previous years.

For this and several other reasons the railroads have been forced to curtail expenses to a great degree. The failure of many of the state railway commissions to approve an intrastate business of the higher rates awarded by the Interstate Commerce Commission has reduced the anticipated earnings so that they will fall considerably below the reasonable return suggested in the Transportation Act. The failure of the federal treasury to pay the railroads millions of dollars due them from the Railroad Administration has further added to the financial embarrassment of the carriers.

This is most unfortunate. There is no question but what the roads will be confronted with a record breaking traffic within a few months. Now is the time, when business is light, for them to go forward strenuously with the work of rehabilitation. Indeed they must do this or they will face failure when they are called upon to handle a big business next year. The wise shipper will also take advantage of the present lull in business to ship as much goods as possible before the carriers again become clogged up with business. It is important also, as suggested in another editorial in this number, that railway employees do their full part in helping to receive more efficient operation.

ELECTRICAL PROGRESS OF THE YEAR

A review of the electrical activities of the year would be incomplete without some mention of the introduction of wireless telegraphy into the railroad field. Even though extensive application of this unique method of communication has not been made it has been tried sufficiently to demonstrate beyond question that it possesses wonderful possibilities for railroad operation in some sections of the country. What is true of the telegraph is equally true of the wireless telephone. Many recent improvements and refinements have been made in wireless equipment that has brought it to a remarkable stage of efficiency.

The greatest obstacle at present to a broader use of wireless equipment on railroads is the fact that it is not generally understood. Wireless phenomena differ so decidedly in most of their manifestations from that of other electrical apparatus that radio installation and maintenance require a special knowledge not susally possessed by the average electrical engineer. In spite of this situation, however, there is reason to believe that wireless apparatus will eventually come into common use on the railroads in certain parts of the country.

The general adoption of electric headlights by all roads this year has carried along with it a number of interesting problems. Among other things, headlight reflectors have become a subject of much discussion; glass and silvered copper reflectors are both used and each kind will probably continue to meet with favor until time has unmistakably proven that one type is better than the other. Another matter that is closely related to the reflector problem is the urgent need for some suitable standard by which the illumination of various headlights may be compared. As defined at present in the Interstate Commerce Commission's regulations the subject contains too many variables. Headlight testing should be so standardized that the exact conditions of the test might be duplicated at any time and place. Such vague expressions as "a clear, dark night," and "a man dressed in dark clothing" should find no place in engineering specifications. They are meaningless and the sooner they are replaced by definite engineering terms the sooner headlight illumination will be put upon a satisfactory basis of comparison.

Another application of electricity to the solution of railroad problems has been coming steadily into prominence during the past year and that is the use of electric tractors and trucks. The most remarkable economies have already been shown with such installations as have been made, and this has been accomplished in spite of the fact that in most cases insufficient effort has been made to organize the handling of this equipment in such a way as to secure the maximum operating efficiency. The maintenance of motor tractors is bound to fall within the scope of the electrical engineer's department, for it is of the utmost importance that such equipment receive the proper care. So much is expected of and performed by this apparatus that there is a temptation to keep it in service for longer periods than is good for the battery. Intelligent supervision is needed to see that the machines are taken out and charged regularly. Maximum efficiency calls for high grade maintenance, but not necessarily expensive maintenance, since a relatively small amount of attention properly directed will keep electric trucks and tractors in first-class condition.

The subject of electrification will not down. While the past year has not witnessed the installation of much electrified line, the advocates of heavy electric traction are extremely active and there has been plenty of evidence that the matter has received more than passing consideration in many quarters. Unfortunately, however, there are almost as many different profiles and traffic conditions as there are railroads and whenever comparisons are attempted they do not carry conviction because there are too many points at variance. Nevertheless the electric locomotive has so successfully demonstrated what it can do under adverse conditions that its possibilities demand recognition. In spite of the high initial cost of electrification there are plenty of instances where electric traction must be eventually adopted. It must be kept in mind that the whole question of heavy electric traction is comparatively young and it is not unreasonable to expect decided improvement in operating economies both on lines already electrified and for such others as will be constructed in the future.

ROUNDHOUSE LIGHTING

The lighting of railroad engine houses usually falls under the jurisdiction of the electrical man and it is probably the most difficult lighting problem he has to deal with. The men who work in the engine house must work in the narrow aisles between the locomotives, in the pits, or in the cabs or boilers. Good overhead lighting in conjunction with portable extension lights would probably best meet the requirements if the buildings were free of smoke and gas. If the overhead lights are placed low, a large number are required; and if high, they become blackened so quickly that they seldom receive proper maintenance.

In cold climates the steam line sometimes comes down so low as to make overhead lighting impracticable and headlights located on the outer and inner circles are resorted to. This keeps the lighting unit down out of the steam and reduces the number of units required to a minimum, but provides a light which may give objectionable glare.

In addition to the difficulties connected with the selecting and location of outlets, is the selection of a conduit and wiring system that will not deteriorate rapidly due to the effect of the locomotive gases.

Suggestions for the lighting of locomotive terminals are offered on page 456 of this issue and there is a brief description of one installation on page 438. These do not solve the problem but are offered as suggestions.

Manufacturers of lamps and lighting fixtures have from time to time issued pamphlets on lighting applications which have been very helpful, but as yet they have not attempted to cover the engine house. Inquiries sent to the *Railway Electrical Engineer* indicate that it is a problem which has not been solved to the satisfaction of many of those concerned and suggestions from the readers will be welcomed. If you have a roundhouse lighting installation that you are proud of let the other fellow know about it through the pages of the *Railway Electrical Engineer*.

THE JANUARY NUMBER

Recently we have heard a great deal concerning the relative merits of steam and electric locomotives, but a large portion of the comparisons have consisted of general statements and abstract claims. It is very clear that electrification at present is a subject which is of much interest to railroad men and it is with this thought in mind that we have planned the January issue of the *Railway Electrical Engineer* so as to contain an unusual number of articles on electrification. These articles are not overburdened with statistics of uncertain value but they will contain many interesting facts concerning this absorbing subject.

NEW BOOKS

Engineering Electricity. By Ralph G. Hudson, assistant professor of electrical engineering, Massachusetts Institute of Technology. 190 pages, 5¼ in. x 7⅞ in. Flexible covers, imitation leather. Published by John Wiley & Sons, Inc., New York.

The obvious purpose in preparing this little volume has been to supply fundamental principles of electrical engineering to technical students who are not specializing in electrical work. It is intended for college and university students and may be used to serve as an introductory text to those students who are pursuing electrical engineering courses. The subject matter has been presented as briefly as is consistent, and the treatment is adapted for those who are familiar with engineering computations and formulae.

The final chapter is devoted to numerous photographic reproductions of various types of electrical machinery and equipment, the many illustrations making it possible for the prospective engineer to secure a very fair idea of electrical apparatus in everyday use.

Electrical Equipment of New Engine Terminal

Motors Used in Machine Shops and on Turntable with Other Facilities Make for Better Service

THE new engine terminal on the New York Central at Minerva, Ohio, is an excellent example of a comparatively small installation where the existing conditions make the use of electrical energy for power, lighting and other facilities a factor to be considered.

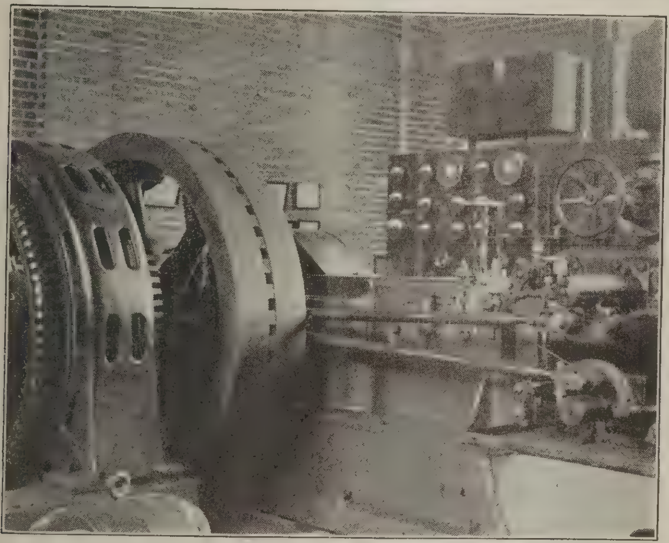


Fig. 1—A Corner of the Operating Room Showing One of the Generator Units and Engine Equipment

This engine terminal consists of a 12-stall engine house, machine shop, store department, office, power house, coaling station, cinder handling plant, water tank and automatic pumping station. The latter, however, is located about three-quarters of a mile from the other facilities mentioned, which are in the vicinity of the power house.

This terminal is on the Alliance division of the New York Central which extends from Phalanx and Dillonvale, Ohio, a distance of 88 miles. There are four passenger trains a day, two each way; the rest of the business is composed largely of coal traffic. This road is not directly connected with the main line of the New York Central, but makes connection via the Erie at Phalanx. Prior to the installation of the new terminal at Minerva, the engine facilities were located at Alliance, Ohio, 25 miles south of Phalanx, the northern terminus. Minerva, the new location, is practically at the center of the division. The old terminal at Alliance was not large enough to handle the constantly increasing business, consequently the new quarters were provided. One of the first problems to be settled was that regarding the source of electrical energy. At Alliance the power and light was purchased from the local power company, but at Minerva the conditions were different—the city plant was inadequate even for the demand of the municipality. It was necessary to provide a power plant with generating facilities sufficiently large to take care of the demands of the engine terminal and proposed future installations. The excess power is at present used in supplying the

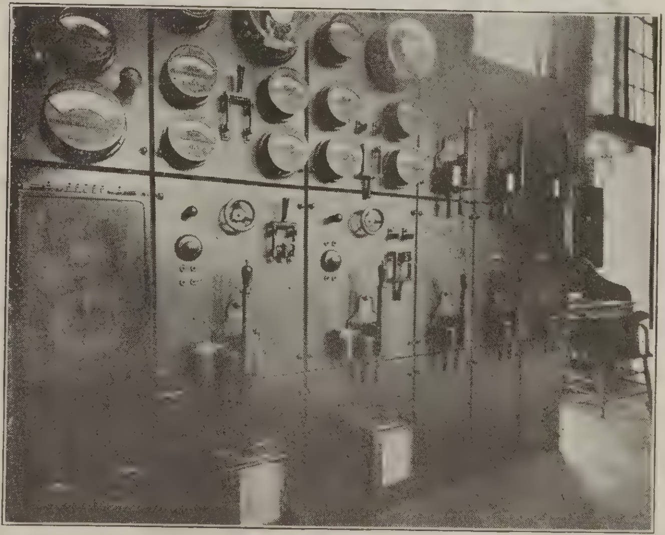


Fig. 2—Switch and Meter Panels of Board in Power House

town with energy during the period of rehabilitation of the city plant. The average load is about 75 kw. and the city requires 100 kw. peak load.

Power House

The power plant, which is a brick structure, houses three Keeler water tube boilers of 250 horse-power, a motor-driven coal crusher, a conveyor and automatic stokers, besides the generating and power distributing equipment. Duplicate generator units are located in the operating room. These are 188 kva. capacity, 480 volt, 3 phase, 60 cycle machines as manufactured by the Electric Machinery Co., Minneapolis, Minn. They are separately excited by 11 kw., 125 volt, 88 ampere machines of the same company's manufacture and are driven at a speed of 225 r.p.m. by Chuse non-releasing Corliss engines. At present only one of these units is in service, the other being held in reserve. A view of one of the alternators and parts of the operating switchboard is shown in Fig. 1. A closeup view of the same board is shown in Fig. 2.

Light and Power

Transmission circuits are carried from the power house in underground conduits to the lighting transformers outside the building and to the various distribution boards located throughout the plant for both power and light. The city service, which is temporary, is carried overhead from the switchboard in iron conduit to the outside of the south building wall and from that point to the step-up transformers on poles. The voltage for lighting service is stepped down to 110 volts, while for power purposes 440 volts is used. The type and arrangement of distribution panel used is shown in Fig. 3.

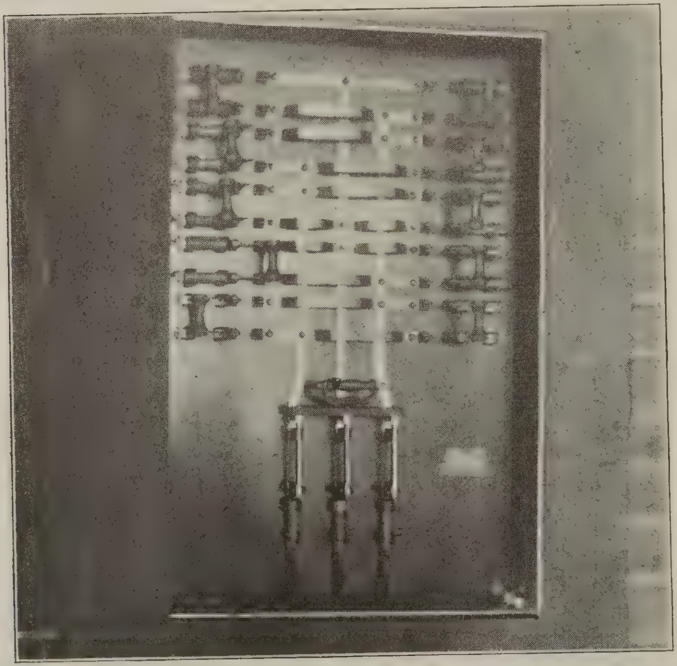


Fig. 3—Type and Arrangement of Distribution Panel Used

The lighting in the engine house consists of single unit fixtures hung from 4¼-in. vertical outlet boxes, each of which is provided with a widespread cone-shaped reflector and lamp. There are 38 of these fixtures distributed as follows: six are hung in the rear opposite alternate stalls, six are hung at the opposite end in a similar manner, while two rows of 13 each are placed between the front and rear sets so as to locate two fixtures between stalls at the most desirable distance apart to give adequate distribution of light. The six rear fixtures are provided with 300 watt lamps, the next row of 13 are provided with 200 watt lamps, while the balance of the fixtures contain 100 watt lamps. On the roof of the engine house on the inner circle at the sides are placed 1,000 watt flood lighting units, which illuminate the turntable and tracks entering the house. Over each of the four side doors entering the engine house is a single 100 watt lamp. All lamps 100 watt and above are type C mazdas.

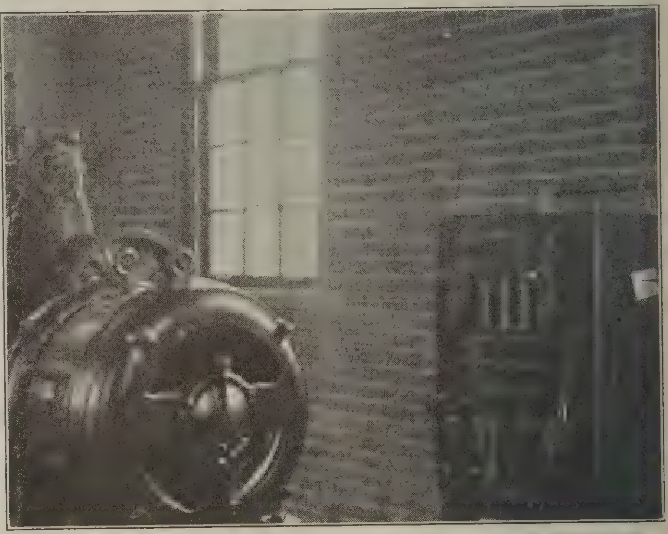


Fig. 4—Motor, Pump and Control Panel in Pump House

Service receptacles for the use of extension cords are provided at convenient locations on one of the supporting columns adjacent to each pit and several outlets are provided for electric welding purposes, one outlet being located between every other stall. The equipment for this service is located about the center of the rear wall of the engine house and consists of a Wilson welder motor generator set. The motor is 440 volts, 3 phase, 60 cycle, which drives a 35 to 40 volt, 125 amperes D. C. generator. The control panel and regulating devices for this outfit are of the Cutler Hammer manufacture and are housed in the cabinet below the motor generator set.

The accompanying table gives an outline of the motors, which are used to drive various facilities; for instance, each machine in the machine shop has a separate motor, each motor is equipped with an automatic push button type starter.

Pump House

In a previous paragraph mention was made of an automatically controlled motor, driving a water pump. This equipment is located three-quarters of a mile from the engine house in a one-story brick building. A view of the driving motor and the pump is shown in Fig. 4. The pump is of the Worthington type and is capable of pumping 350 gallons per minute. It is driven by a 20 horse-power motor, which in turn is controlled by the panel equipment shown in the illustration. No attendant is required to operate the apparatus, as it is automatically stopped and started when the water reaches certain heights in the tank at the engine terminal. The control of this particular feature is accomplished by means of a float in the tank and it was only necessary to run one additional wire to the three phase power circuit from the tank to the pump house in order to provide the control circuit.

TABLE SHOWING MOTORS USED FOR VARIOUS FACILITIES

Facility	Type	H.P.	Motor voltage	Phase	Cycle	R.P.M.
Machine Shop—						
Milling machine	Induction	7.5	440	3	60	1,200
Drill press	Induction	15	440	3	60	1,200
Bolt threader	Induction	5	440	3	60	1,200
Lathe (large)	Induction	15	440	3	60	900
Lathe (small)	Induction	5	440	3	60	900
Emery grinder	Induction	5	400	3	60	1,140
Planer	Induction	15	440	3	60	600
Coal handling plant 2	Induction	15	440	3	60	1,160
Power House—						
Conveyor	Induction	7.5	440	3	60	865
Coal crusher	Induction	15	440	3	60	865
Cinder handling	Slip ring	22	440	3	60	1,145
Fan house	Induction	20	440	3	60	900
Turntable	Slip ring	30	440	3	60	1,145
Pump house	Induction	20	440	3	60	900

Advantages of Steam and Electric Locomotives

A. W. Gibbs, chief mechanical engineer of the Pennsylvania System, was one of the speakers at the joint meeting of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers held in New York on October 22, and reported in the *Railway Electrical Engineer* for November, page 387. The discussion of the paper prepared by Mr. Gibbs was not available when the first account of the meeting was published and an abstract is therefore presented below.

Discussion by A. W. Gibbs

After reading the papers on steam versus electric operation of railroads, I cannot but feel that both Messrs. Muhlfeld and Armstrong have been a bit too enthusiastic. Both methods of operating have their advantages and both have decided limitations.

In Mr. Armstrong's case his data is largely derived from mountain electrification where the electric locomotive is undoubtedly at its best and the steam at its worst, and he has compared with it a type of steam locomotive whose coal and water rate is more than double that of locomotives which are especially designed for such service. Then on this mountain performance he reasons from the particular to the general application of electric operation. True, he puts in a disclaimer as to the particular steam locomotives referred to representing the best modern practice, which brings up the question—Why cite them at all?

It is not at all certain that the speed advantage claimed is by any means true where the steam locomotive is designed for the work.

Mr. Armstrong gives a comparative statement of the performance of two steam and one electric locomotive to which exception can be taken because the steam locomotives do not represent the last word as to those available, and the electric locomotive is on paper.

The table shown herewith gives data for a 2-10-0 type steam locomotive of which over 100 are in regular service and of which fortunately very full information is available from the locomotive testing plant. These locomotives were expressly designed to do all of their work within the economical range of steam distribution, the required power being obtained by increase in size of cylinders and steam pressure. While I have given the power at nearly the speed mentioned by Mr. Armstrong, the performance is excellent at double the speeds given, but the sacrifice in drawbar pull—from nearly 60,000 pounds at 14.7 miles per hour to about 43,000 pounds at 25.3 m.p.h.—would not be justified. The figures given are within the range where stoker firing is as economical as expert hand firing, with the additional advantage that the stoker does not get tired.

This is a special design in which the advantage is that it cannot be worked at uneconomical points of cut-off. At speeds and pulls where the usual design is also worked at an economical range its performance is about the same.

2-10-0 TYPE STEAM LOCOMOTIVE

Weight in working order	371,000 lb.
Weight on drivers	342,050 lb.
Weight on engine and tender	523,000 lb.
Drawbar effort at 14.7 miles per hour, 45 per cent cut-off	58,900 lb.
Gross tons (2 per cent grade)	1,280
Trailing tons	1,019
Coal per D.H.P. at this speed and cut-off	2.8 lb.
Tractive effort at 22 miles per hour, 40 per cent cut-off	42,500 lb.
Gross tons	923
Trailing tons	662
Coal per D.H.P.	3.2 lb.
Tractive effort at 25.4 miles per hour, 45 per cent cut-off	43,600 lb.
Gross tons	948
Trailing tons	687
Coal per D.H.P.	3.8 lb.

The Mallet performance given in Mr. Armstrong's paper is evidently that of one of the large compound locomotives. In all of these locomotives there is a tendency to choke up with increases of speed, due to increase of back pressure.

The same arrangement of limited maximum cut-off used in the 2-10-0 locomotive already described has been embodied in a simple Mallet now running. In brief, the improvements in the steam locomotive, if properly availed of, have much narrowed the field of economical electrification.

Stand-by Losses. While these losses are actual and large it is very difficult to fix their value, as they are so much affected by the use made of the locomotive. Where the average monthly mileage is low the stand-by loss is presumably high, and it is a part of good operation to bring up the average mileage as high as possible. When all is said the electric locomotive has still an advantage with respect to stand-by losses, provided there are sufficient trains in motion to smooth out the total demand on the power plant, which is assumed to be steam operated.

Weather. The independence of the electric locomotive of severe weather is another undoubted advantage, not so much because of the performance of the motors but rather from the avoidance of losses and delays due to ash-pit work and to frozen pipes and other parts, incidental to the presence of water on the steam locomotive.

Liability to Interruption. Electric operation is dependent on uninterrupted connection with the source of power. In the event of breakage of the line, especially of the overhead construction, the trains in the section involved are dead and cannot get themselves out of the way of the repair trains. On large systems it is customary to make great changes in the assignment of locomotives to clear up congestion at any point on the system; also, to avail of diversion routes on which steam trains may be moved around obstructions on the main line. The fact that the steam locomotive is a self-contained power plant is an immense advantage in this respect. In electric operation there is not this freedom of movement.

Speeds. The question of speed is evidently treated from the freight standpoint, for there has never been any question as to the speed capacity of well designed passenger locomotives being far beyond that permitted by the rules. As I see it the feature of high speed of trains is of less importance than uniformity of speeds of different trains. If tonnage trains had the same speed as preference trains, and could thus avoid the great delay due to side tracking of trains of inferior rights, far more would be accomplished than the mere saving in time over the division due to the increased speed.

Extent of Electrification. Where electrification is contemplated a very serious question is: What shall be its extent? Naturally the desire would be to wipe out as many as possible of the extensive accessories to steam operation. If, however, it becomes necessary to operate steam trains over the electrified section, it will obviously be necessary to retain water stations and possibly fuel stations, provided the electrified section is sufficiently long. This operation of steam locomotives under their own power over electrified sections would be necessary in case of redistribution and possibly in case of diversions where the electrified section formed part of the diverted line. Therefore, the claim for economy in doing away with these features of steam operation would probably not be realized.

Mr. Muhlfeld's Paper. Mr. Muhlfelt ignores the fact that the modern improvements which have so added to the performance of the steam locomotives are potential only. For instance, it is very possible and common by indifference to so carry water in the boiler that the superheater becomes merely a steam dryer and its value disappears. In many cases because of neglect a damper mechanism or from dirty flues little benefit is derived from improved appliances. Modernizing of steam locomotives calls for intelligent use of the devices, which will come when the old spirit of loyalty returns.

Conclusions. The electric locomotive or electric operation has in many cases undoubted operating advantages because the power is generated in quantity at few sources and the power on any one train is not limited by the capacity of a self-contained portable power plant; sustained speeds are possible due to independence of fuel and water stations and, as a result of both these conditions, better use can be made of a given stretch of road.

Electrification does not at all obviate the numerous class of delays due to the train itself, such as hot boxes or other of the numerous derangements which when combined so much retard the movement over the road. Electrification does not obviate that class of delay arising from necessary classification on line of the road to meet terminal requirements. Where the terminal conditions limit the capacity of the road as a whole electrification is not the remedy.

On level grade roads where the existing steam locomotives will handle all the cars that can be safely moved in one train, the value of electrification will be principally the absence of stops and probable reduction in overtime.

The claims for fuel saving have been greatly overstated by not making comparisons with the potential performances of the best steam locomotives.

Of course, with steam locomotives the maintenance or the indifference of those operating them, both on the road and elsewhere, may to a large extent nullify the savings possible.

Stand-by losses must exist probably with both classes of operation, but especially with steam, and may be any percentage of the total consumption, depending on the actual use of the locomotives.

The relative cost of repairs of both classes of equipment cannot be fairly stated at the present time because maintenance conditions are so abnormal and because the most modern locomotives of both classes are too new to have reached a stable condition, this being especially true of the electric one. While the indications are that the maintenance of the electric locomotive will be less than that of the steam, it must be remembered that the electric locomotives are dead affairs without the necessary electric generating, transmitting, converting and track appliances, all of which are an added expense, due solely to electrification; hence the cost of maintenance of all of these, in addition to that of all of the locomotives, divided by the locomotive mileage, is the real treasury cost of maintenance per locomotive mile.

Personally, I believe that many roads now operated by steam will be operated in whole or in part electrically, but that this will not be decided in the off-hand manner advocated by some.

It is to be noted that practically all of the electrification on steam railroads so far have been based on local conditions. In the electrifications in and around cities a moving cause has been the elimination of smoke and other objectionable features incidental to steam operation, and the possibility of increasing the capacities of the passenger terminals. On the Milwaukee road it was the utilization of available water power. On the Norfolk & Western it was to secure increase in capacity on a congested mountain division with tunnel complications. It is fair to assume that other electrifications will be similarly governed by local conditions.

If, after careful consideration of the road, based on actual train sheets for the heaviest actual or probable congested operation; the capacity and number of active and available locomotives required; crediting the operation with incidental savings which may be effected, and eliminating expenses peculiar to steam operation; it appears that there would be economy in electrification, either from actual savings or better operation, or both, it still remains for the management of the railroad to decide whether the money required can be spent to better advantage for electrification than for some other features of the general operation.

• • • •

Station at Karemskaya, Siberia, on the Trans-Siberian—A Typical Station on This Line

A Study of the Electric Arc Welding of Steel[*]

An Investigation Into the Properties of Arc-Fused Metal. Tabulated Data of Results Obtained

By Henry S. Rawson
Physicist, Bureau of Standards, Washington, D. C.

A FUSION weld is fundamentally different from all other types in that the metal of the weld is essentially a casting. The arc-fusion weld has characteristics quite different from other fusion welds. The results of a study of the properties of the arc-fused metal which has been carried out by the Bureau of Standards may be of sufficient interest to warrant presentation before this body. For details the Technologic Paper of the Bureau upon this subject should be consulted.

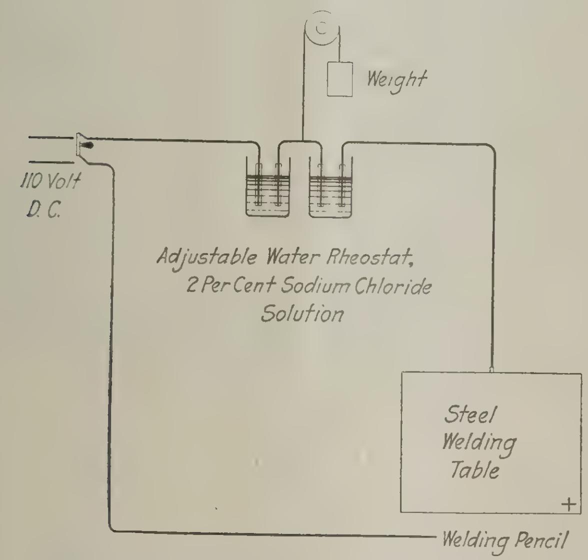


Fig. 1—Diagram of Apparatus Used in the Preparation of the Specimens of Arc-Fused Metal

The application of arc welding in the shipbuilding industry is one of the most important and extensive applications which has ever been proposed for this method. During the year 1918, at the request of and with the coöperation of the Welding Research Sub-Committee of the Emergency Fleet Corporation, an extensive program was outlined by the Bureau of Standards for the study of this type of welding. The principal object of the research was the determination in an empirical way by actual welding tests carried out by skilled operators the relative values and merits of the different types of electrodes or welding pencils which are available commercially for the purpose. Due to changed conditions, however, at the close of the year 1918, the original program was modified and shortened very considerably.

In drawing up the modified program it was decided to make the study of the characteristic properties of the fused-in metal, the primary object of the investigation, the study of the merits of the different types of electrodes being a secondary one. Since the metal of any weld produced by the electric-arc fusion method is essentially a casting, as there is no refinement possible as in some of the other methods, it is apparent that the efficiency of the weld is dependent upon the properties of this arc-fused metal. Hence a knowledge of its properties is of fundamental importance in the study of electric-arc welds.

Though the results available at present are not as conclusive throughout the entire series of examinations made as might be desired, it is believed that they contribute very materially to our knowledge of the properties of the fused-in metal which is ultimately the deciding factor as to the serviceability of the electric-arc weld. The investigation included a study of the composition changes which accompany the fusion of the metal, the determination of the mechanical properties of the arc-fused metal together with the examination of the structure of the metal after fusion, in the endeavor to explain the observed mechanical and chemical characteristics.

The specimens required for the study of the mechanical properties of the arc-fused iron were prepared for the most part at the Bureau of Standards, direct current being used in all the operations. The apparatus used is shown diagrammatically in Fig. 1. By the use of automatic recorders the voltage and current were measured and records were taken at intervals during the preparation of a specimen.

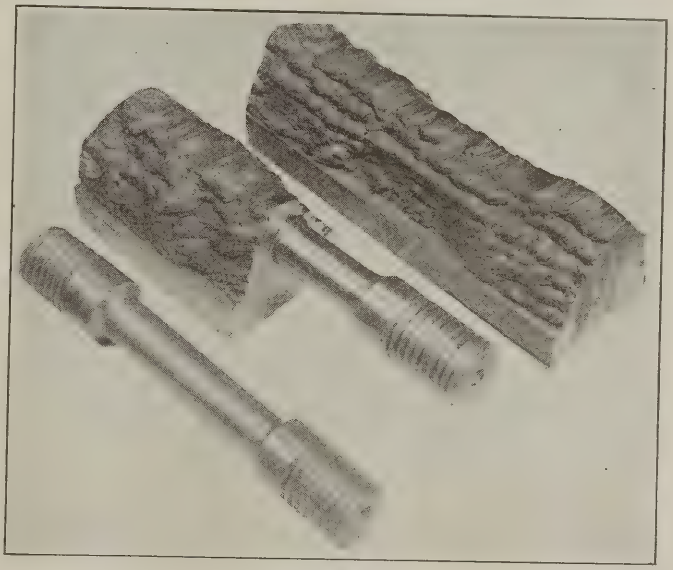


Fig. 2—Blocks of Arc-Fused Metal With Tension Specimen Cut Therefrom

Since the investigation was concerned primarily with the properties of the arc-fused metal, regular welds were not made. Instead the metal was deposited in the form of blocks (Fig. 2), each one being large enough to permit a tension specimen (0.505 in. in diameter, 2 in. gage length) to be machined out of it. Although the opinion is held by some welders that the properties of the metal of an arc weld are affected materially by the adjacent metal by reason of the interpenetration of the two during fusion, it was decided that the change of properties of the added metal induced by fusion alone, was of fundamental importance and should form the basis of any study of arc welding. The method adopted also permitted the use of larger specimens with much less machining than would have been possible had the metal been deposited in the usual form of a weld. The block of arc-fused metal was built up on the end of a section of ½-in. plate of mild steel (ship plate). When a block of sufficient size had been built up, it, together with the portion of the steel plate immediately beneath, was sawed off from the remainder of the steel plate. The tension specimen was turned entirely out of the arc-fused metal. No difficulty whatever was experienced in machining the specimens.

---

[*] From a paper presented before the Washington Section of the American Society of Mechanical Engineers.

In general, in forming the blocks, the fused metal was deposited as a series of "beads," so arranged that they were parallel to the axis of the tension specimen which was cut later from the block. For purposes of comparison in a few specimens, the metal was deposited in beads at right angles to the length of the block. In all the specimens, after the deposition of each layer, the surface was very carefully and vigorously brushed with a stiff wire brush, to remove the layer of oxide and slag which formed during the fusion. There was found to be little need to use the chisel for removing this layer.

Tension specimens only were prepared from the arc-fused metal. It is quite generally recognized that the tension test falls very short in completely defining the mechanical properties of any metal; it is believed, however, that the behavior of this material when stressed in tension is so characteristic that its general behavior under other conditions of stress, particularly when subjected to the so-called dynamic tests, i. e., vibration and shock, can be safely predicted from the results obtained. In order to supplement the specimens made at the bureau a series was also prepared by one of the large manufacturers of equipment for electric welding to be included in the investigation.

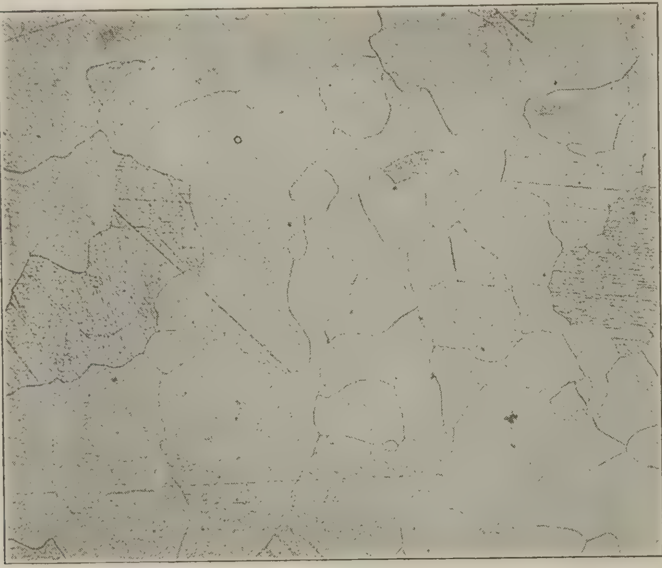


Fig. 3—Microstructure of "Pure Iron" Type of Electrode Used (X100)

Two types of electrodes were used as material to be fused. These differed considerably in composition and were chosen as representative of a "pure" iron and a low-carbon steel (see microstructures in Figs. 3 and 4), the approximate carbon content of the two being respectively 0.02 and 0.15 per cent. Each type was obtained in sizes ranging from ⅛ in. in diameter to ¼ in., so that a considerable range of current densities was possible. The electrodes were used both in the bare condition and after being slightly coated with a paste of an oxidizing and refractory nature, the purpose being to prevent excessive oxidation of the metal of the electrode during fusion and to form also a thin protective coating of slag upon the fused metal.

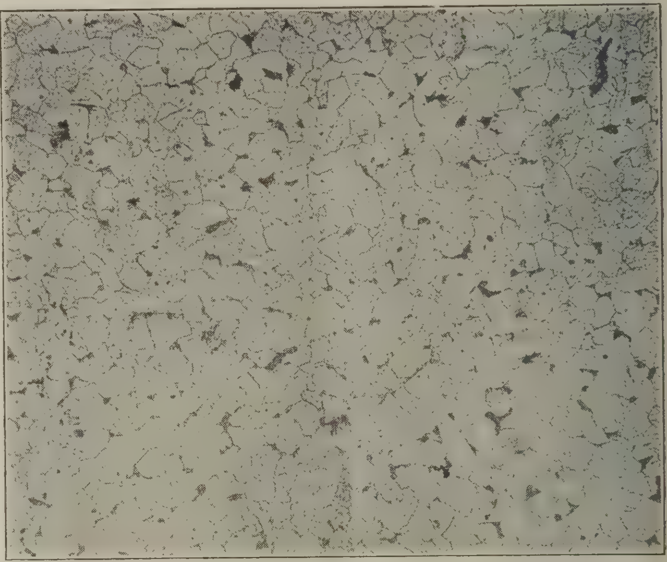


Fig. 4—Microstructure of Low-Carbon Steel Electrode Used (X100)

Changes in Composition of Electrodes as a Result of Fusion

In general, the effect of the fusion in the arc is to render the metal of two electrodes quite similar in composition. The data summarized in Table 1 are typical of the changes.

TABLE 1—PERCENTAGE COMPOSITIONS OF ELECTRODES BEFORE AND AFTER FUSION

Type	A		A		B	
Size, in.	⅛		3/16		⅛	
	Before	After	Before	After	Before	After
Carbon	0.058	0.031	0.022	0.010	0.15	0.024
Silicon	0.33	0.007	0.16	0.012	0.06	9.008
Manganese	0.042	tr.	0.038	tr.	0.47	tr.
Phosphorus	0.002	0.005	0.002	0.002	0.018	0.002
Sulphur	0.057	0.036	0.040	0.033	0.021	0.035
Nitrogen[1]	0.0030	0.143	0.0040	0.126	0.0032	0.140

---

[1] Average of several determinations on different electrodes of same size and type.

The most noticeable change in composition is the increase in the nitrogen content of the metal. In general the increase was rather uniform for all specimens. In Fig. 5 the average nitrogen contents found for the different conditions of fusion are plotted against the corresponding current densities. Though no definite conclusion seems to be warranted, it may be said that, in general, the percentage of nitrogen taken up by the fused iron increases somewhat as the current density increases. With the lowest current densities used the amount of nitrogen was found to decrease appreciably. Other investigators in this line have reported an increase in nitrogen content under similar conditions.

Mechanical Properties of the Arc-Fused Metal

When it is considered that the metal which forms a fusion weld is essentially a casting, it is not surprising that there should be a very considerable difference between the mechanical properties of the metal in the form of electrodes or welding pencils and the same after fusion. The average tensile properties of the two types of electrodes are as given in Table 2.

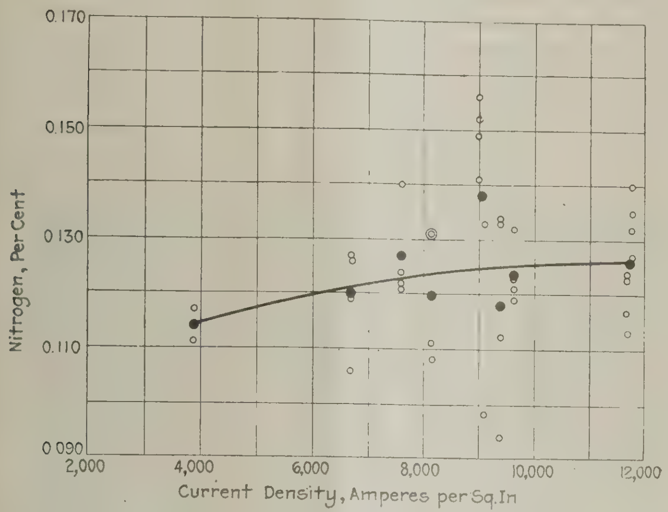
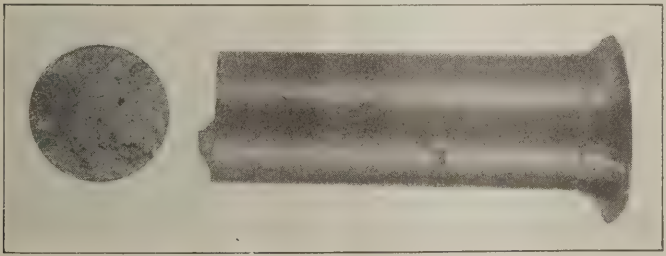


Fig. 5—Relation of the Nitrogen Content of the Arc-Fused Metal to the Current Density

TABLE 2—AVERAGE TENSILE PROPERTIES OF PURE-IRON (A) AND LOW-CARBON STEEL (B) ELECTRODES

Type of Electrode	Ultimate Strength, lb. per sq. in.	Proportional Limit, lb. per sq. in.	Elongation in 2 In., per cent	Reduction of Area, per cent
A	61,000	40,000	14	68
B	86,000	63,000	6	55
	67,000	37,000	15	61

The size of the electrode tested and the physical state of the metal, that is, the amount of cold working the metal received, cause rather wide variations in the properties. After fusion, however, the properties are very different, as shown in Table 3.



Figs. 6 and 7—Fractured End and Side Views of a Tension Specimen After Test. Nearly All of the Specimens Upon Fracturing Revealed a Defect Similar to the One Shown Above

TABLE 3—TENSILE PROPERTIES AND HARDNESS OF ARC-FUSED METAL

Type of Electrode	Average Ultimate Strength, lb. per sq. in.	Average Yield Point, lb. per sq. in	Elongation in 2 in., per cent	Reduction of Area, per cent	Brinell Hardness	Shore Hardness
A (bare)[1]	48,900	35,300	7.9	10.0	103	16.6
A (covered)[1]	46,600	34,600	8.5	9.0	103	16.6
B (bare)[1]	48,800	34,200	8.5	10.5	103	16.0
B (covered)[1]	47,400	32,200	9.9	13.8	103	16.0
C[2]	49,900	32,700	11.0	17.6	113	17.0

[1] "Bare" electrodes were those which were used in the conditions as received; "covered" ones were coated as mentioned in the text.

[2] These specimens were prepared by a large welding firm and submitted to the Bureau to be included in the series.

The variations for the specimens of any particular type of electrode are rather wide, usually within the limits of ± 6 per cent. No definite conclusions could be drawn concerning the merits of the various electrodes. All the specimens have properties similar to those of steel castings of a rather inferior grade; the variations noted are of the order which might be expected for such cast steel of inferior quality. There does not appear to be any material advantage so far as the properties of the metal obtained were concerned in coating the electrodes. The specimens which were prepared by different operators compare very favorably with each other. The most striking feature in the mechanical properties is the low ductility of the metal.

The characteristic appearance of the specimens after testing, illustrating their behavior when stressed in tension until rupture occurs, is shown in Figs. 6 and 7. The features shown are quite typical of the set of specimens. The fracture in all cases revealed interior flaws and defects. Although the results of the tension test appeared to indicate a fair elongation, examination of the specimens showed that the measured elongation does not truly represent a property of the material, but is due rather to the interior defects which indicate lack of perfect union of succeeding additions of metal during the process of fusion. The surface features of the specimens after stressing are very similar to those seen in the type of defective steel familiarly known as "flaky," which was a source of much discussion and delay of production during the progress of the war.

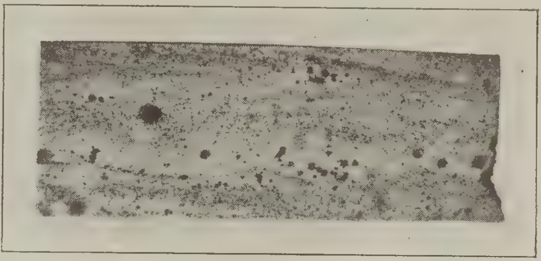


Fig. 8—Longitudinal Section of a Tension Specimen of Arc-Fused Metal. Natural Size; Polished and Etched With Copper-Ammonium Chloride Solution to Accentuate Internal Defects

As previously noted, specimens were prepared for the purpose of showing the relation between the direction in which the stress is applied and the manner of deposition of the metal. The metal was deposited so that the beads of fused metal extended across the piece rather than lengthwise, hence the beads were at right angles to the direction in which the tensional stress was applied. The results of the tension tests are given in Table 4 and show that these two specimens (1 and 2) were decidedly inferior to those prepared in the other manner.

Structural Features

The general condition of the metal resulting from the arc fusion is shown in Figs. 8 and 9, which represent longitudinal sections of tension specimens. The metal in all of these specimens was found to contain a considerable number of cavities and oxide inclusions; these are best seen after the polished surfaces are etched with a 10 per cent aqueous solution of copper-ammonium chloride. In many of the specimens the successive additions of metal are outlined by a series of very fine inclusions (probably oxide) which are revealed by the etching. There appears to be no definite relation between the soundness of the metal and the conditions of deposition, i. e., for the range of current density used; nor does either type of electrode used show any decided superiority over the other with respect to porosity of the resulting fusion. The condition of the material prepared by experienced "practical" welders is quite similar to that prepared by the Bureau.

Table 4—Tensile Properties of the Specimens Tested

Specimen	Ultimate Strength, lb. per sq. in.	Proportional Limit, lb. per sq. in.	Elongation in 2 In., per cent	Reduction of Area, per cent
1	40,450	22,500	6.5	8.5
2	39,500	22,500	4.0	3.0

It is to be expected that the microstructure of the material after fusion will be very considerably changed, since the metal is then essentially the same as a casting. It has some features, however, which are not to be found in steel as ordinarily cast. The general type of microstructure was found to vary in the different specimens and to range from a condition which will be designated as "columnar" to that of a uniform fine equi-axed crystalline arrangement. This observation held true for both types of electrodes, whether bare or covered. In the examination of cross-sections of the blocks of arc-fused metal it was noticed that the equi-axed type of structure is prevalent throughout the interior of the piece and the columnar is to be found generally nearer the surface, i. e., in the metal deposited last. It may be inferred from this that the metal of the layers which were deposited during the early part of the preparation of the specimen is refined considerably as to grain size by the successive heatings to which it is subjected as additional layers of molten metal are deposited. The general type of structure of the tension bars cut from the blocks of arc-fused metal will vary considerably according to the amount of refining which has taken place as well as the relative position of the tension specimen within the block. In addition it was noticed that the columnar and coarse equi-axed crystalline condition appears to predominate with fusion at high current densities.

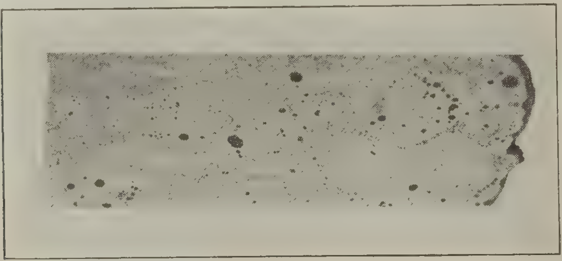


Fig. 9—Longitudinal Section of a Tension Specimen of Arc-Fused Metal. Natural Size; Polished and Etched With Copper-Ammonium Chloride Solution to Accentuate Internal Defects

In all of the specimens of arc-fused metal examined microscopically there were found numerous tiny globules of oxide as shown in Fig. 11. In general they appear to have no definite arrangement but occur indiscriminately throughout the crystals of iron.

A type of unsoundness frequently found is that shown in Fig. 10, which will be referred to as "metallic globule inclusions." In general these globules possess a microstructure similar to that of the surrounding metal but are enveloped by a film, presumably of oxide. It seems probable that they are small metallic particles which were formed as a sort of spray at the tip of the electrode and which were deposited on the solidified crust surrounding the pool of molten metal directly under the arc. These solidified particles apparently are not fused in with the metal which is subsequently deposited over them, i. e., during the formation of this same layer and before any brushing of the surface occurs.

The most characteristic structural feature of the metal after fusion is the presence of numerous needles or plates within the ferrite crystals. The general appearance of this feature is shown in Fig. 11. The number and distribution of these needles were found to vary greatly in different specimens; in general, however, they are most abundant in the columnar and in the coarse equi-axed crystals. Their distribution within the individual crystals indicates that they are arranged along the crystallographic planes.

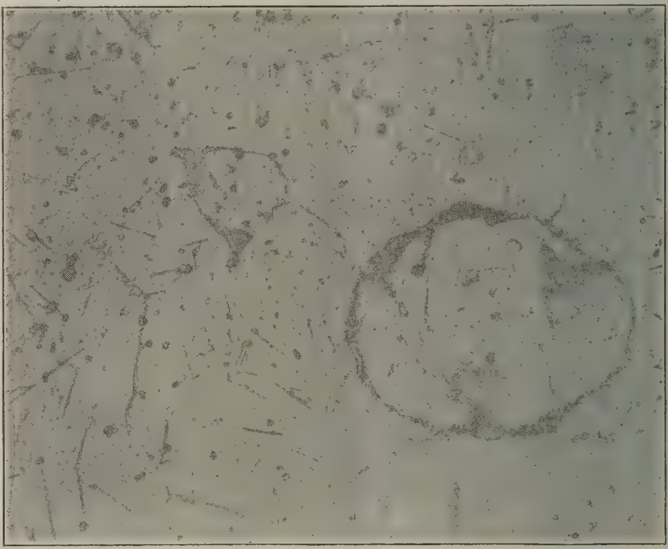


Fig. 10—Microscopic Evidence of Unsoundness. The Globule at the Right Is Surrounded By a Film of Oxide, and the Fracture of Specimens When Tested in Tension Originates in Such Unsound Areas

The usual explanation of these plates is that they are due to the nitrogen which is taken up during the fusion. Other suggestions offered by different investigators at various times are to the effect that they are due to oxide and to carbide. While it is not to be denied that the oxide content increases to a very pronounced extent as is evident from the microscopic examination of any specimen of weld metal whatever—the characteristic appearance of such oxide inclusions, as well as their behavior when the specimen is heated for long periods (e.g., 6 hours at 1,000 deg. Cent. was used in some of the experiments), makes the suggestion that oxide forms the substance of such plates or needles seem very improbable. Likewise the suggestion of carbide may also be dismissed. The tendency during fusion is for the carbon to be "burnt out" of the metal and only a small amount remains. In practically all of the specimens enough carbide (as pearlite) may be found to account for the carbon content of the metal as revealed by the chemical analysis. The fact that the nitrogen content increases during fusion and also that iron which has been nitrogenized under known conditions has a structure practically identical with that of the arc-fused metal, is very strong evidence in favor of the view that the nitrogen is responsible. See Fig. 12. When once combined with the iron the nitrogen is eliminated only with great difficulty. A heating of six hours in vacuo at 1,000 deg. Cent. (1,830 deg. Fahr.) reduced the nitrogen by about only 50 per cent of its initial value.

The pronounced effect of the nitrogen which is gained by the metal during fusion upon the thermal characteristics of the iron in the partial suppression and lowering of the transformation changes is shown in Fig. 14. The suggestion that such a pronounced change in the structure of the metal should have a similar pronounced effect upon the mechanical properties of the metal is a reasonable one. Numerous microscopic examinations were made with the aim of demonstrating to what extent the properties are affected, particularly whether these plates determine to any pronounced extent the course of the fracture of the specimen when broken in tension. It appears, however, as shown in Fig. 13, that the path of rupture is not affected appreciably by these so-called "nitride-plates." The effect of the grosser imperfections of the metal, i. e., oxide inclusions and films, "metallic globule" inclusions, and lack of adhesion between successive layers of the weld metal, is so much greater than any possible effect of the nitride plates in determining the mechanical properties of the specimen as a whole that the conclusion appears to be warranted that this feature of the structure is a matter of relatively minor importance in ordinary arc welds.

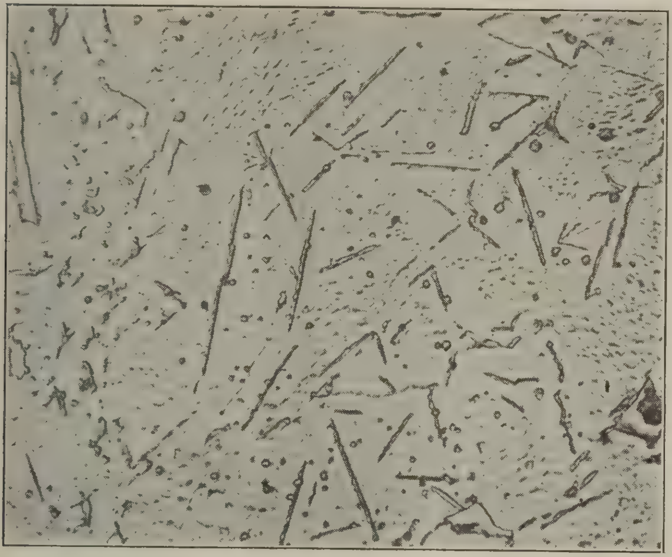


Fig. 11—Characteristic Feature of Arc-Fused Iron. The "Needles" or "Plates" Are Due to the Increase Which Occurs in the Nitrogen Content During Fusion. (X500)

In arc-fusion welds in general the mass of weld metal is in intimate contact with the parts which are being welded, so that it is claimed by many that because of the diffusion and intermingling of the metal under repair with that of the electrodes the properties of the latter are considerably improved. The comparison shown in Table 5 somewhat supports this claim. The nearest comparison found available with the bureau's specimens are some of those of the welds designated as the "Wirt-Jones" series reported by H. M. Hobart of the Research Committee of the American Welding Society. The welds were of the 45-deg. double-V type made in ½-in. ship plate; the specimens for test were of uniform cross-section, 1 in. by ½ in., the projecting metal at the joint having been planed off even with the surface of the plates, and the test bars were so taken that the weld extended transversely across the specimen near the center of its length. The electrodes used were similar to those designated as type B in the bureau's investigation.

In any consideration of electric-arc welding it should be constantly borne in mind that the weld metal is simply metal which has been melted and has then solidified *in sit.* The weld is essentially a casting, though the conditions for its production are very different from those ordinarily employed in the making of steel castings. The metal loses many of the properties it possesses when in the wrought form, and hence it is not to be expected that a fusion weld made by any process whatever will have all the properties that metal of the same composition would have when in the forged or rolled condition. A knowledge of the characteristic properties of the arc-fused iron is then of fundamental importance in the study of the electric-arc weld.

The peculiar conditions under which the fusion took place also render the weld metal quite different from similar metal melted and cast in the usual manner. It is seemingly impossible to fuse the metal without serious imperfections. The mechanical properties of the arc-fused metal are therefore dependent to an astonishnig degree upon the skill, care, and patience of the welding operator. The very low ductility shown by specimens when stressed in tension is the most striking feature observed in the mechanical properties of the material as revealed by the tension test. As explained above, the measured elongation of the tension specimen does not truly indicate a property of the metal. Due to the unsoundness already referred to in the discussion of the structure, the true properties of the metal are not revealed by the tension test to any extent. The test measures, largely for each particular specimen, the adhesion between the successively added layers, which value varies considerably in different specimens due to the unsoundness caused by imperfect fusion, oxide and other inclusions,

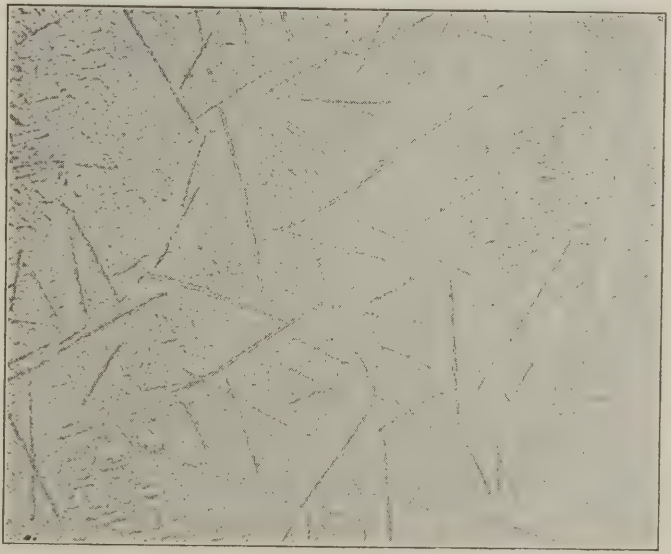


Fig. 12—Nitrogenized Iron, Showing Change in Structure Caused by Heating in Ammonia. Electrolytic Iron Was Nitrogenized by Heating it Several Hours (approx. 650 degrees C.) in Ammonia, and the Change in Structure is Due to the Nitrogen Which is Taken Up. Compare With Fig. 11. (X500)

tiny enclosed cavities and similar undesirable features. The elongation measured for any particular specimen is due largely, if not entirely, to the increase of length resulting from the combined effect of the numerous tiny imperfections which exist throughout the sample.

Table 5—Comparison of Bureau of Standards and Wirt-Jones Tests

Bureau of Standards Tests			Wirt-Jones Tests		
Electrode	Ultimate Strength, lb. per sq. in.	Elongation in 2 In,, per cent	Electrode	Ultimate Strength, lb. per sq. in.	Elongation in 2 In., per cent
⅛ in.	48,700	8.0	⅛ in.	54,900	10.0
⁵⁄₃₂ in.	48,600	10.0	⁵⁄₃₂ in.	59,800	9.0

That the metal is inherently ductile, however, is shown by the behavior upon bending as recorded in the microstructure of the bent specimen. The formation of slip bands within the ferrite grains to a very marked extent occurs under such conditions and is evidence of a high degree of ductility. It appears, however, that the grosser imperfections are sufficient to prevent any accurate measurement of the real mechanical properties of the metal from being made. The conclusion appears to be warranted, therefore, that the changes of composition which the fusion entails, together with the unusual features of microstructure which accompany the composition change, are of minor importance in making a determination of the strength, durability, and other properties of the arc weld.

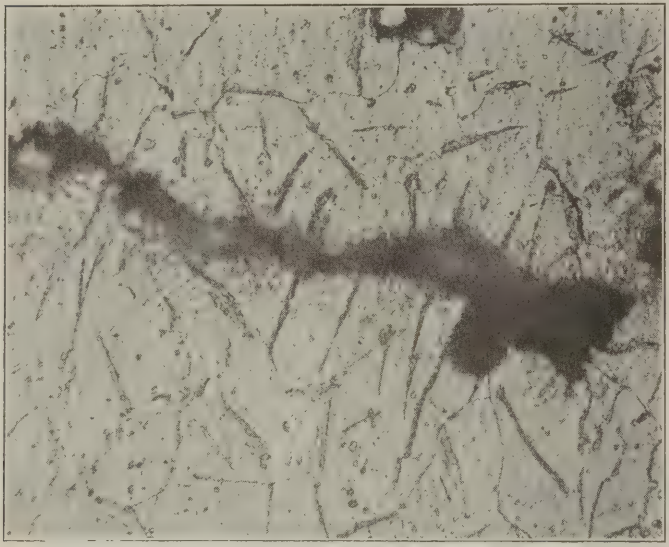


Fig. 13—Relation of Path of Rupture to the Microstructure of Arc-Fused Iron. The Course of the Crack or Tear in the Metal Which Was Produced by Stressing in Tension Does Not Appear to Have Been Influenced Appreciably by the "Nitride Plates." (X500)

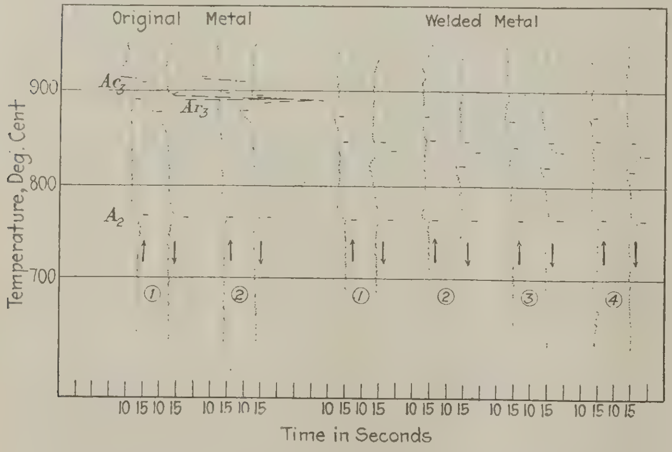


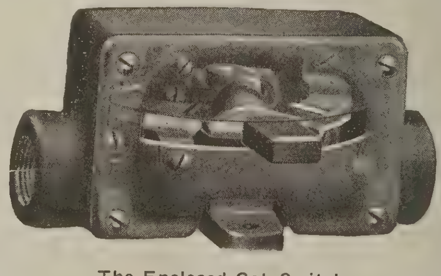
Fig. 14—Effect of Arc Fusion Upon the Thermal Characteristics of Low Carbon Steel. The Metal Originally Contained 0.02 Per Cent Carbon; After Fusion the Composition is Very Similar Except That It Has Taken Up Nitrogen to the Extent of 0.13 Per Cent

Since the specimens used in the work described were prepared in a maner quite different from the usual practice of arc welding, no definite recommendations applicable to the latter can be based upon the results. It appears, however, from the results obtained that the two types of electrodes used, i.e., "pure" iron and low-carbon steel, should give very similar results when applied to practical welding.

This is due to the changes which occur during the melting, so that the resulting fusions are essentially of the same composition. In fact, the most valuable conclusion which the results of the study warrant is that an arc weld is essentially a casting the properties of which are determined to a very large extent by the skill, ingenuity, and experience of the operator. If this essential characteristic of arc welds is borne in mind, the method will not be used in places where it is evident from the conditions of stresses existing in service that a casting should not be used, and it will also determine in innumerable cases that arc welding is the most efficient method to be considered.

New Enclosed Cab Switch

The illustration shows a new enclosed cab switch manufactured by the Pyle-National Company, Chicago. The design permits its use in any position and its application is not confined only to the locomotive; it may be installed wherever a rugged, double-throw switch is required in a full conduit installation. Its armored shell protects the terminals and surfaces from injury and prevents persons from possible injurious contact, when higher than headlight voltage is used.



The Enclosed Cab Switch

The stationary as well as the moving contacts are of heavy bronze with a current carrying capacity of 60 amperes. The handle is molded of an insulating material.

A spring lock retains the blade in the neutral or either of the contact positions. Provision is made for the reception of wire terminals and the interior is enclosed in a cast body which measures 6 in. by 4 in. by 2 in.

A slot in the removable cover guides the blade into the contacts and the supporting lugs are so located that the switch may be installed in various positions.

Controllers for Alternating Current Motors

Diagrams of Control Apparatus Used in the Operation of Various Polyphase Induction Motors

By Gordon Fox

IT will be the purpose of this chapter to illustrate and discuss some of the more common and simple magnetic controllers for use with polyphase induction motors. Controllers for squirrel cage motors will be considered first, those for wound rotor motors following.

Primary Resistance Starter

Magnetic starters of the primary resistance type are quite commonly used, particularly with the smaller motors. A starter of this type is illustrated in Fig. 1, the connections being given in Fig. 2. The starter comprises a main line switch and a control circuit switch, a main line contactor, a time element accelerating relay, a three pole accelerating contactor and two overload relays of the time element trip, instantaneous reset type. The operation is as follows:

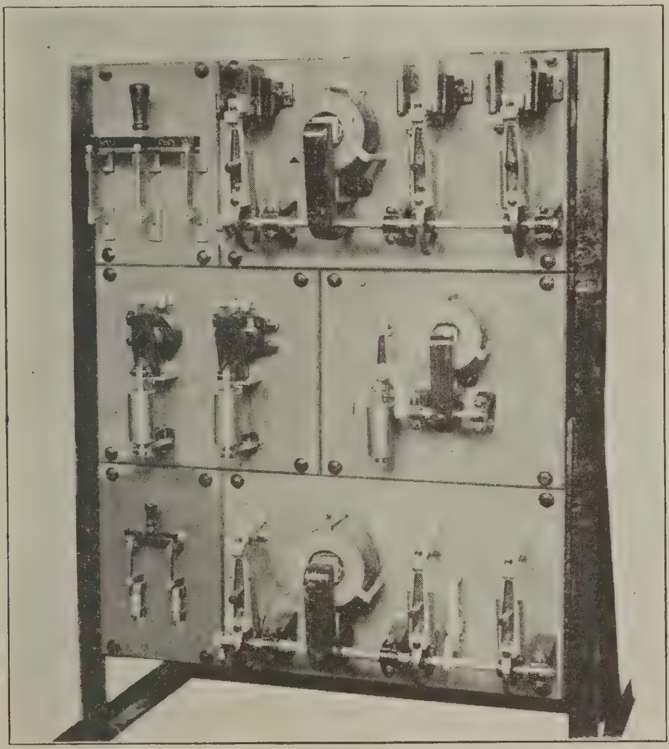


Fig. 1—Primary Resistance Starter for Squirrel Cage Induction Motor

When the start button is depressed the pilot circuit through the closing coil of *No. 1* contactor is completed. Closure of that contactor connects the motor primary winding to the line with resistance in series in all phases. An auxiliary contact on *No. 1* contactor causes this unit to remain closed after the start button is released. Simultaneously with the closure of *No. 1* contactor the accelerating relay coil is energized. Closure of the relay contracts is delayed by a dash pot on this contactor type relay. After the prescribed time these contacts close. The closing coil of *No. 2* accelerating contractor is then energized. Closure of this contactor short circuits the primary accelerating resistance. No-voltage protection is secured in that failure of voltage will cause all contactors to open. The line contactor will not then close until the "start" button is depressed. Momentary opening of an overload relay or pressing the "stop" button has a like effect.

Magnetic starters of the primary resistance type are frequently provided with resistance in but two legs of the circuit. They are simpler to that extent. However, an unbalanced voltage is impressed upon the motor phases with this scheme. The motor attempts to balance the phase voltages and may circulate rather high local currents in so doing. Except for occasional starting of small motors the use of resistance in all three phases is considered, by the writer, as preferable.

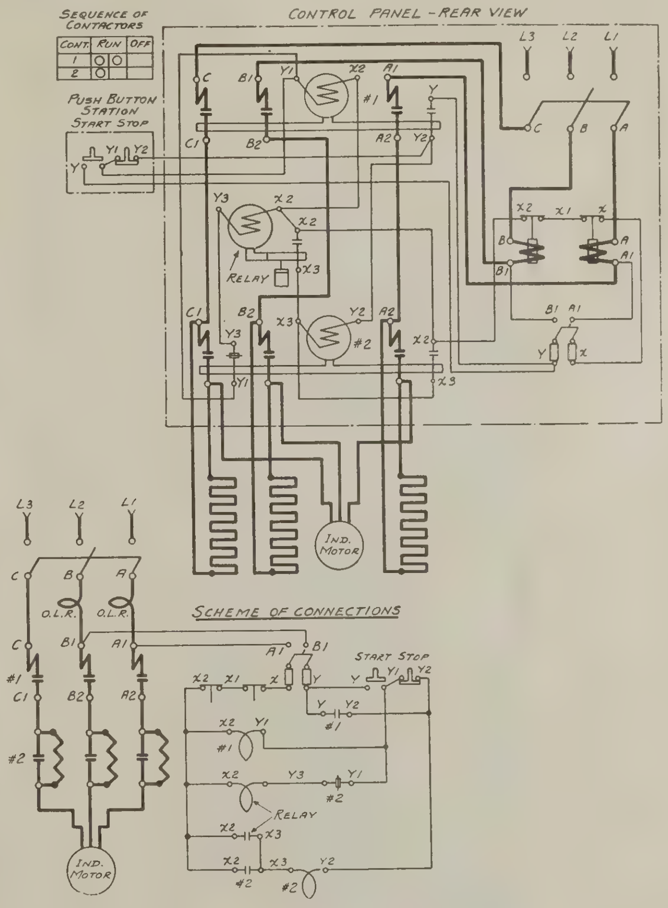


Fig. 2—Wiring Diagram of Primary Resistance Starter for Squirrel Cage Induction Motor

Primary resistance starters need have ordinarily but one accelerating step. The initial current rush causes relatively high drop in the resistance, causing rather low voltage to be impressed upon the motor. As the motor current falls off, the resistance drop decreases, automatically increasing the voltage impressed upon the motor. The squirrel cage motor has its lowest torque per ampere at standstill, the torque increasing as the motor accelerates. A value of resistance which will pass sufficient current to start the motor will easily accelerate it. A possible exception is in the case of a load which increases rapidly with the speed.

It is to be noted that, the heavier the load to be started, the greater is the resistance drop and the lower the voltage impressed upon the motor. It is therefore necessary, where starting conditions may be severe, to reduce the resistance to a value which will permit the required starting voltage at all times. The primary resistance type of starter has advantage in simplicity, low first cost, relative ease and low cost of repair and provides continuous acceleration without a throw over interruption. It has the disadvantage of limited torques, higher starting current peaks and lesser economy. These disadvantages are often nominal. The primary resistance starter has much to recommend its use, particularly for the smaller motors.

Transformer Type Starters

Magnetic contactor panels, based on the auto starter principle, are in common use. A panel of this type is illustrated in Fig. 3. The connections are shown in Fig. 4. The panel comprises a two pole line contactor and a four pole starting contactor, mechanically interlocked. A current limit accelerating relay is interlocked with the starting contactor. A transfer relay is used to govern the throw over operation. No voltage protection is obtained through use of a voltage relay. An auto transformer of the air cooled type is supported at the rear of the panel. This transformer is supplied with taps for adjusting the starting voltage. The panel illustrated carries fuses for overload protection. In the diagram overload relays are indicated. The action of the control is as follows:

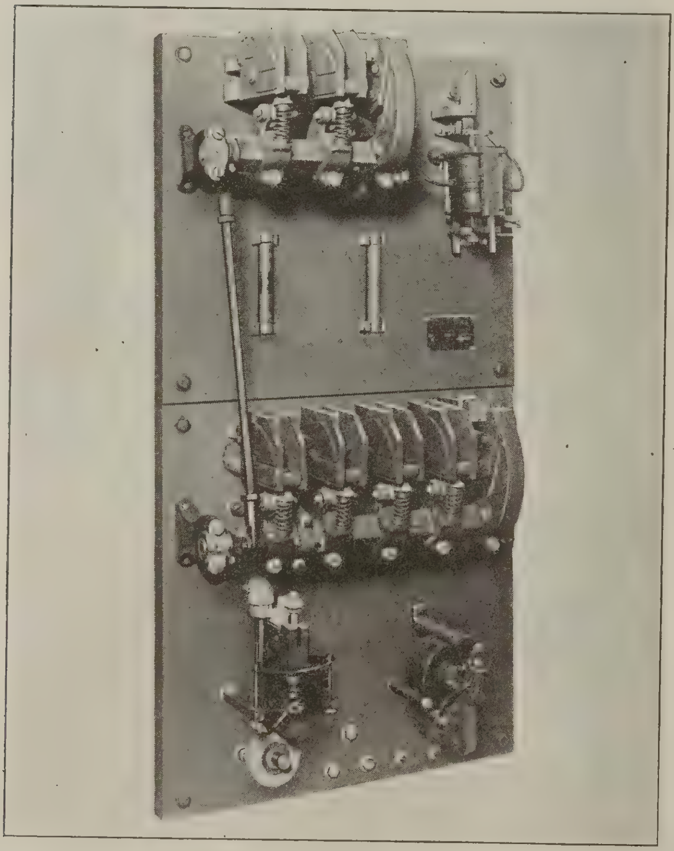


Fig. 3—Magnetic Starter for Squirrel Cage Induction Motor. Auto-Transformer Type

When the start button is depressed the voltage relay coil is energized, closing this relay. An auxiliary contact on this relay causes it to remain closed after the start button is released. Closure of the voltage relay causes the closing coil of the four pole starting contactor to be energized, the pilot circuit passing through the transfer relay. When the four pole starting contactor closes the motor is connected to the low voltage taps of the auto transformer. The series coil of the accelerating relay is now in circuit in one motor lead. When the four pole contactor closes the accelerating relay is released and mechanically free to drop. It is held up, however, by the starting current peak through the series coil. When this current is sufficiently reduced the relay drops. This closes a pilot circuit through the transfer relay coil. When the transfer relay is energized its plunger is raised. This causes the contact at *1* to open and that at *2* to close. The auxiliary contact at *L3* also closes, completing a holding circuit to retain the transfer relay in the new position.

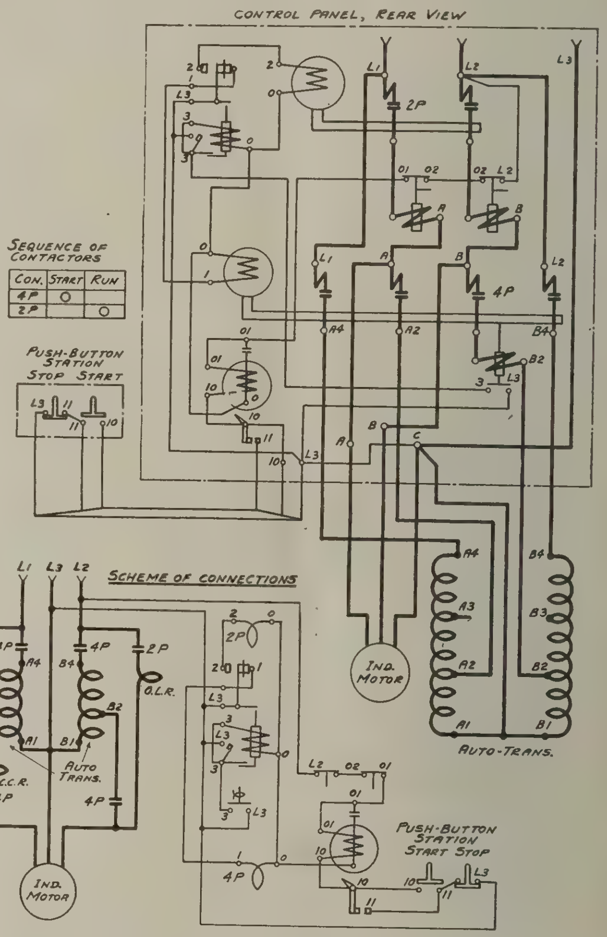


Fig. 4—Wiring Diagram of Magnetic Starter for Squirrel Cage Induction Motor. Auto-Transformer Type

The opening of transfer relay contact *1* interrupts the circuit of the closing coil of the four pole starting contactor, causing this unit to open. The closure of transfer relay contact *2* establishes a pilot circuit through the closing coil of the two pole line contactor, causing it to close. This connects the motor directly to the line, bringing the overload relays into circuit also.

Opening of the voltage relay interrupts the pilot circuit of the transfer relay coil, allowing the latter to open and remain open. When the transfer relay opens it causes the line contactor to open, so that the motor will not start except in the regular cycle. Opening of either overload relay or depressing the stop button opens the circuit of the voltage relay, causing it to open the transfer relay and line contactor in turn.

Another magnetic starter using auto transformers is illustrated in Fig. 5, the connections being given in Fig. 6. The general make up of this panel is similar to that described above with the exceptions that a voltage relay is not used, a single relay combines the functions of current limit and transfer and a three phase auto transformer is supplied. This control functions as follows:

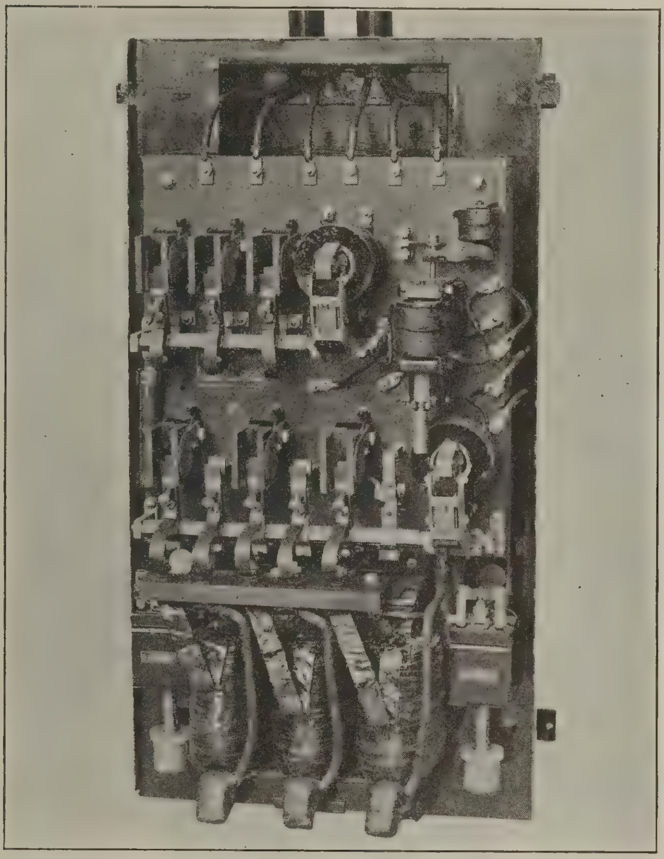


Fig. 5—Magnetic Starter for Squirrel Cage Induction Motor

When the start button is depressed a pilot circuit is closed through the closing coil of starting contactor *No. 1*. This pilot circuit passes through a contact of the current limit transfer relay. Closure of contactor *No. 1* connects the auto transformer in circuit and starts the motor at reduced voltage. An auxiliary contact on contactor *No. 1* serves to maintain the circuit of the closing coil after the start button is released, retaining the contactor closed.

When contactor *No. 1* closes, both the series and the shunt coil of the current limit relay *E* are energized. The shunt coil lifts its plunger, releasing the plunger of the series coil. The latter drops when the current has fallen to the set value. When this plunger drops the pilot circuit *4-6* is broken and *4-5* is established. This interrupts the pilot circuit of contactor *No. 1*, causing it to open. The pilot circuit for line contactor *No. 2* is completed so that it closes, connecting the motor across line voltage. It may be noted that the pilot circuit for contactor *No. 2* passes through an interlock *7-1* on contactor *No. 1* so that the former cannot close until the latter has opened. The small coil *1-5* on the relay *R* is connected in multiple with the closing coil of contactor *No. 2*. This coil holds the current limit transfer relay in its second position so long as the motor continues to run.

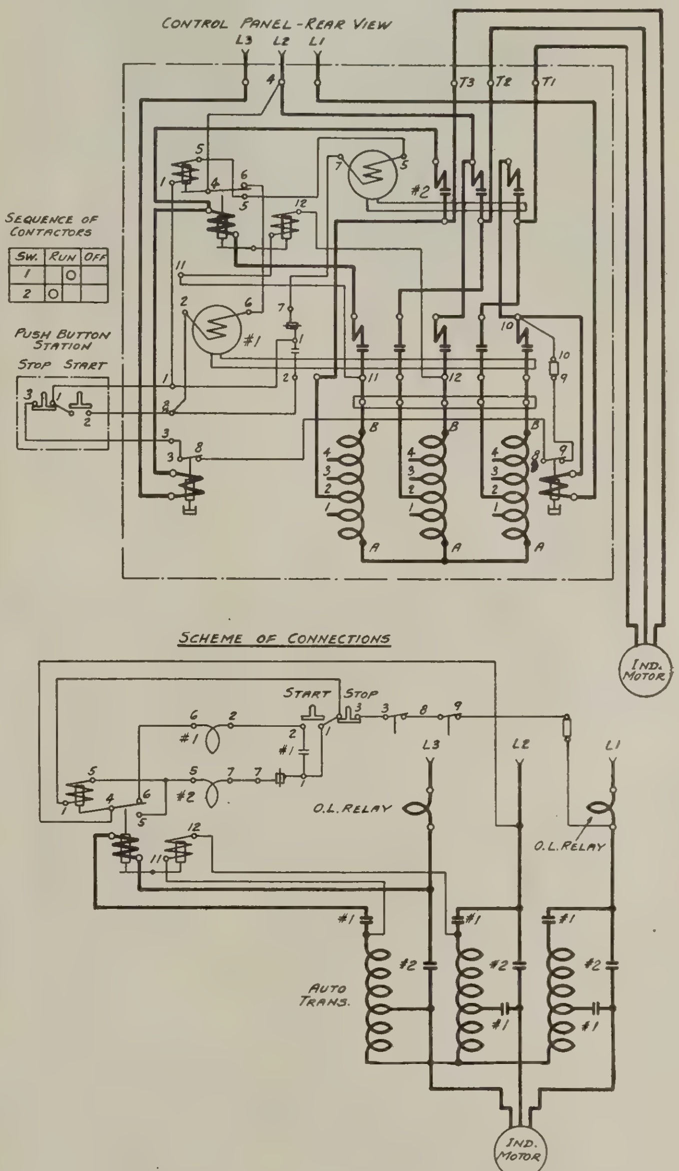


Fig. 6—Wiring Diagram of Magnetic Starter for Squirrel Cage Induction Motor. Auto-Transformer Type

Upon failure of voltage, coils *No. 2* and *R* are deenergized. The contactors all open and a start must be made in the regular cycle. Depressing the stop button or opening of an overload relay opens the pilot circuit of coils *No. 2* and *R*, causing them to open and necessitating a new start.

The auto transformer type of magnetic starter for squirrel cage induction motors has the advantage of providing definite starting voltages, selective through use of taps, the starting voltages being independent of the load.

It has the further advantage that the line current is reduced below motor current in the ratio of transformation. This reduces the starting peaks and disturbances and maintains economy. The current limit principle of acceleration protects the motor but exposes the auto transformer to damage. If the current in starting does not fall sufficiently to permit this relay to function, the starting connections are maintained and a transformer burnout is likely.

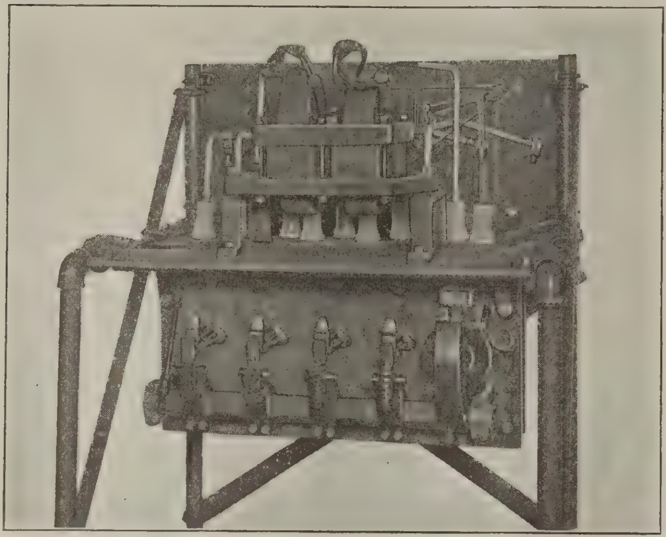
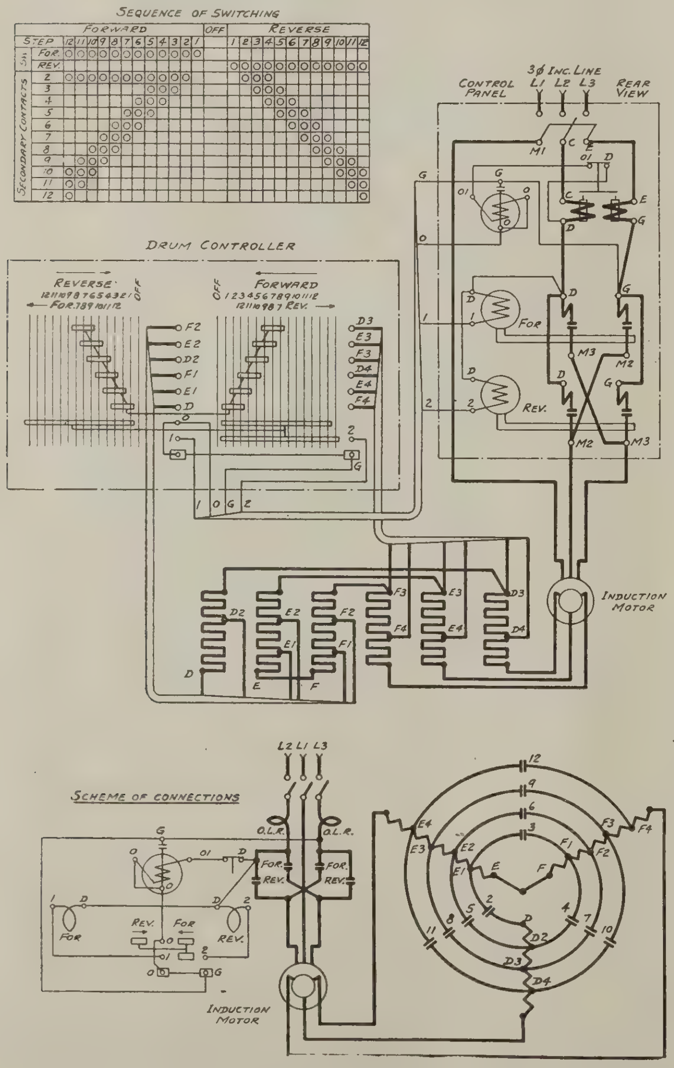


Fig. 7—Magnetic Starter for High Voltage Squirrel Cage Induction Motor. Oil Tank Removed

The controllers described above are suitable for use with motors of low primary voltage. For use on circuits above 600 volts, magnetic starters are supplied which function along similar lines. The main contactors, however, are arranged to be submerged in oil to assist in suppressing the arcs. An equipment of this type is shown in Fig. 7. This type of equipment is well suited for the ordinary installation involving but a few operations per day. Where very frequent starting is involved it is necessary to supply high voltage aid break contactors in place of the oil immersed contactors. In either case it is proper to install an oil switch ahead of the control panel and to arrange the overload protection to act in conjunction with this oil switch. This is necessary because neither the oil immersed nor the air break contactors are suitable to care for high voltage short circuit conditions.



SEQUENCE OF SWITCHING

		FORWARD												OFF	REVERSE											
STEP		12	11	10	9	8	7	6	5	4	3	2	1		1	2	3	4	5	6	7	8	9	10	11	12
SW.	FOR.	○	○	○	○	○	○	○	○	○	○	○	○													
	REV.														○	○	○	○	○	○	○	○	○	○	○	○
SECONDARY CONTACTS	2	○	○	○	○	○	○	○	○	○	○	○				○	○	○								
	3								○	○	○						○	○	○							
	4							○	○	○								○	○	○						
	5						○	○	○										○	○	○					
	6					○	○	○												○	○	○				
	7				○	○	○														○	○	○			
	8			○	○	○																○	○	○		
	9		○	○	○																		○	○	○	
	10	○	○	○																				○	○	○
	11	○	○																						○	○
	12	○																								○

Fig. 8—Combination Drum and Magnetic Control for a Wound Rotor Induction Motor

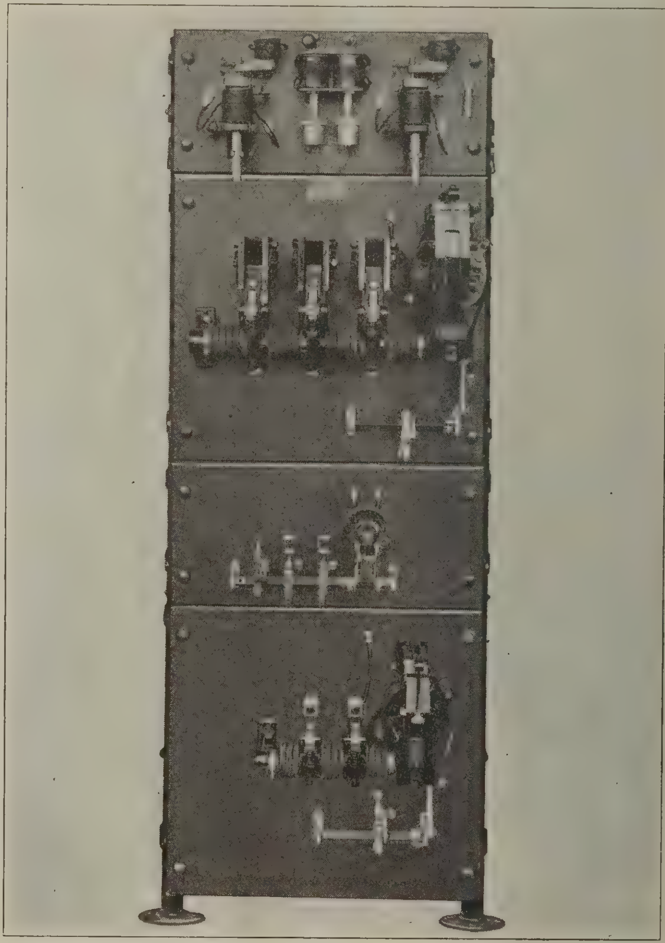


Fig. 9—Control for Wound Rotor Induction Motor Using Primary Current Limit Relays

Control of Wound Rotor Motors

The control of a wound rotor induction motor involves switching in both primary and secondary circuits. The control may be full magnetic, involving contactors handling primary and secondary current. Not infrequently manual control, usually an oil switch, is supplied to handle the primary circuit, magnetic contactors being provided for the secondary. On the other hand, magnetic primary control is sometimes provided in conjunction with manual secondary control. A diagram for an equipment of this type is shown in Fig. 8. A main line knife switch, overload relays and voltage relay are supplied on the primary panel. There are also two pole primary contactors for interrupting or reversing the primary circuit. The drum carries pilot circuit segments and fingers which control the primary contactors and the voltage relay reset. The drum handles the motor secondary circuits, cutting out resistance in steps in the three phases in sequence.

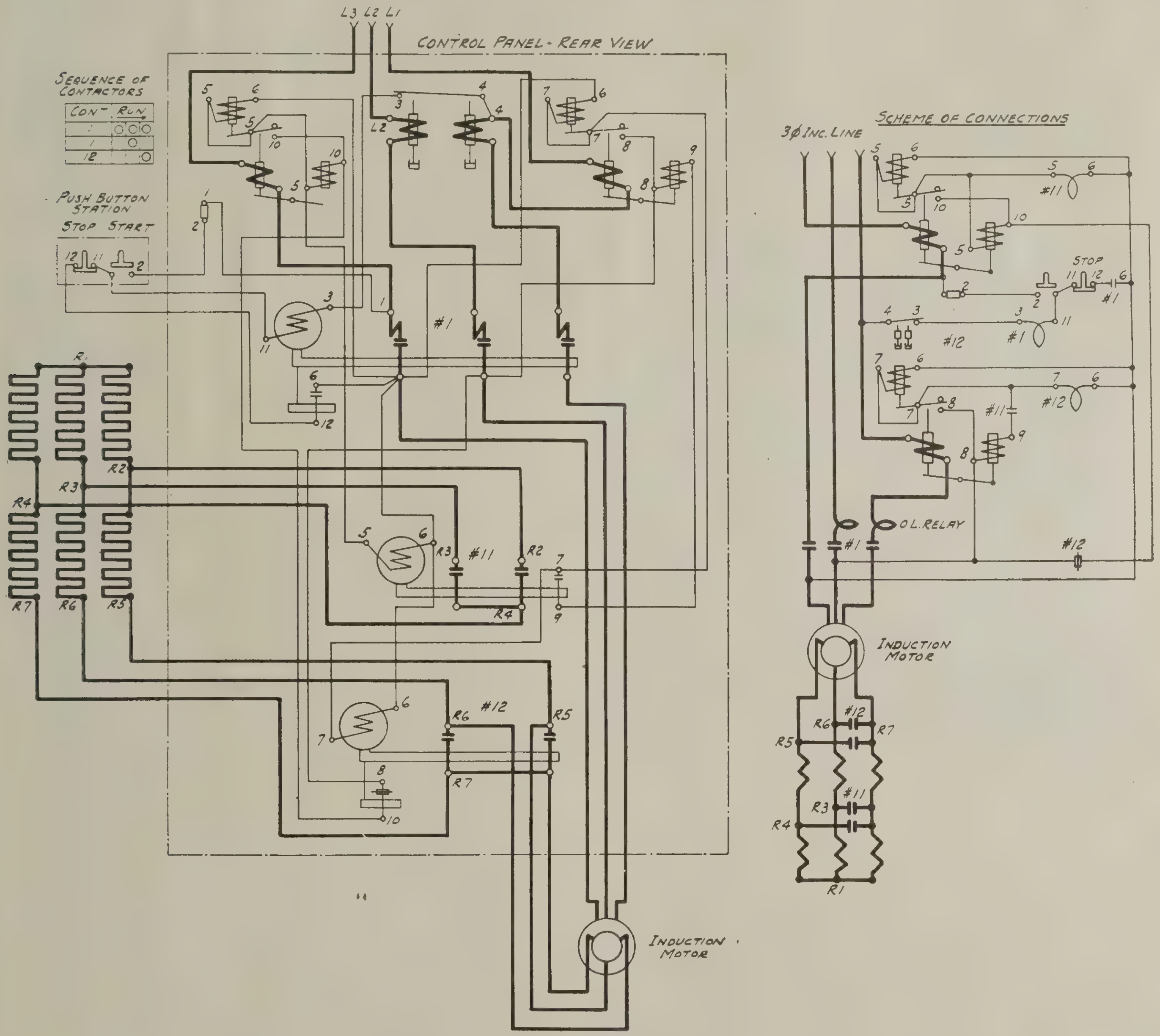


Fig. 10—Wiring Diagram for Control for Wound Rotor Induction Motor, Using Primary Current Limit Relays

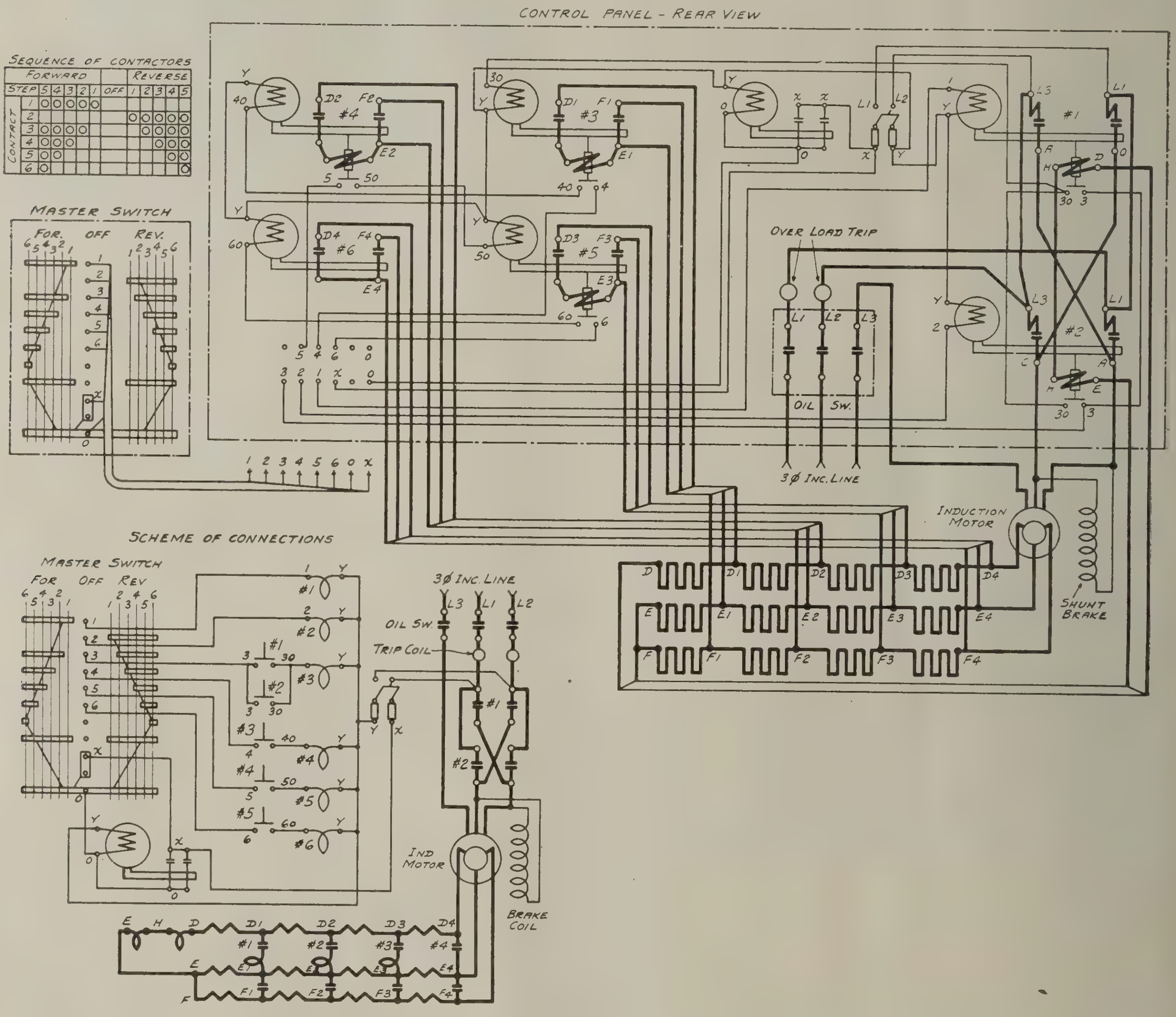
A simple non-reversing full magnetic controller is shown in Fig. 9. The connections are given in Fig. 10. The control as shown comprises a three pole primary contactor, two two-pole secondary contactors, two primary current limit accelerating relays, two overload relays and the necessary resistance. The action may be outlined briefly.

When the start button is depressed, the coil of primary contactor *No. 1* is energized, causing that contactor to close, connecting the motor primary winding across full line voltage. The motor secondary circuit is permanently connected to the accelerating resistance. On the first step all this resistance is in circuit. The amount of current flow and torque produced on this point depends upon the resistance values. The average equipment will pass about 200 per cent current and develop a proportional torque. When contactor *No. 1* closes its auxiliary contact completes a holding circuit which passes through the main contacts of this contactor.

When contactor *No. 1* closes its main contact completes a pilot circuit which includes an interlock on contactor *No. 12* and coil *5-10* of one transfer relay. As the reactance of this coil is high, most of the voltage in this circuit occurs across this coil, there being insufficient voltage across the closing coil to close contactor *No. 11*. Coil *5-10* being energized, lifts its plunger. This permits the plunger in the current coil of this relay to drop as soon as the current through it falls to a sufficiently low value, according to the relay adjustment. This relay is usually adjusted to close at about full load primary current.

When contactor *No. 11* closes its auxiliary contact brings into play the other current limit accelerating relay, which functions in like manner to close contactor *No. 12* as soon as the current in the series coil of the relay drops to the set value. When contactor *No. 12* closes, the current and torque again increase but fall off shortly to a value determined by the load demand.

The controller described above is a comparatively simple unit of its type, illustrating essentials. A similar control may be supplied having primary reversing contactors, a larger number of accelerating steps, etc. These are variations in application, not in principle.



SEQUENCE OF CONTRACTORS

		FORWARD						REVERSE				
STEP		5	4	3	2	1	OFF	1	2	3	4	5
CONTACT	1	○	○	○	○	○						
	2							○	○	○	○	○
	3	○	○	○	○				○	○	○	○
	4	○	○	○						○	○	○
	5	○	○								○	○
	6	○										○

Fig. 11—Wiring Diagram of a Full Magnetic Controller for Wound Rotor Induction Motor

It is to be noted that the current limit relays of the above described controller are electrically interlocked and are governed by the series coils carrying primary current. The primary current and secondary current of a wound rotor induction motor are approximately proportional, the primary winding carrying an additional magnetizing current. It is therefore possible to actuate the current limit relays by secondary current as well as by primary current.

The controller shown in Fig. 11 is a reversing type magnetic control for a wound rotor induction motor, with current limit acceleration governed by secondary circuit single phase relays. The connections of this control are shown in Fig. 12. A primary oil circuit breaker is provided ahead of the primary contactors, the overload relays acting upon this oil switch. The two pole reversing contactor units are mechanically interlocked. There are four secondary accelerating contactors, all two pole units. A pilot circuit switch, voltage relay, drum type master and resistors complete the equipment.

On the off position of the master the circuit of the voltage relay is made, closing that relay, which will then remain closed unless voltage fails. Reversing contactors are governed by segments *1* and *2* of the master, according to rotation desired. These contactors accomplish reversal of a primary phase.

When the primary contactors close, the motor starts with full accelerating resistance in circuit. The series relays mechanically released by the reversing contactors are connected in the wye of the secondary circuit. The initial inrush of current retains the released relay up until the current falls to the value for which the relay is adjusted. When this relay closes it energizes the coil of the first accelerating contactor *No. 3*, providing the master is thrown at or beyond second point so that segment *3* is energized.

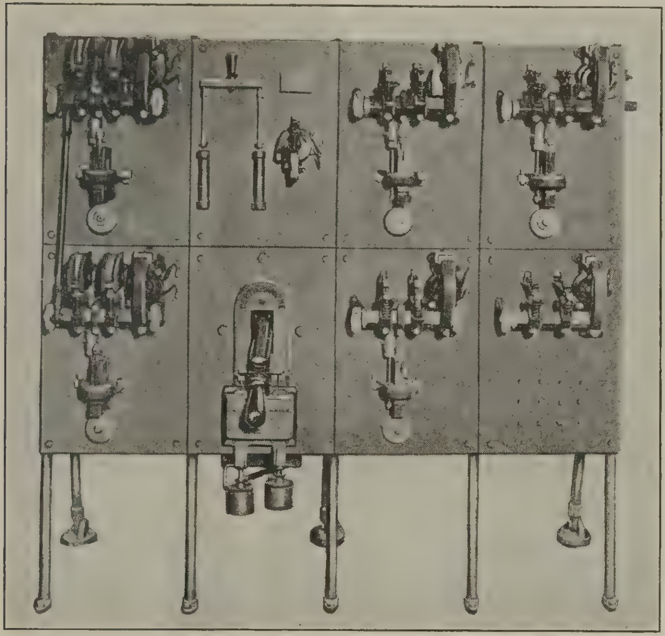


Fig. 12—Full Magnetic Controller for Wound Rotor Induction Motor

In like manner accelerating contactors *4-5-6* close in sequence, each governed by the series relay in the secondary circuit as introduced by the previous accelerating contactor and governed also by successive points and segments on the master. Closure of these accelerating contactors accelerates the motor until it finally operates at full speed with the accelerating resistance short circuited.

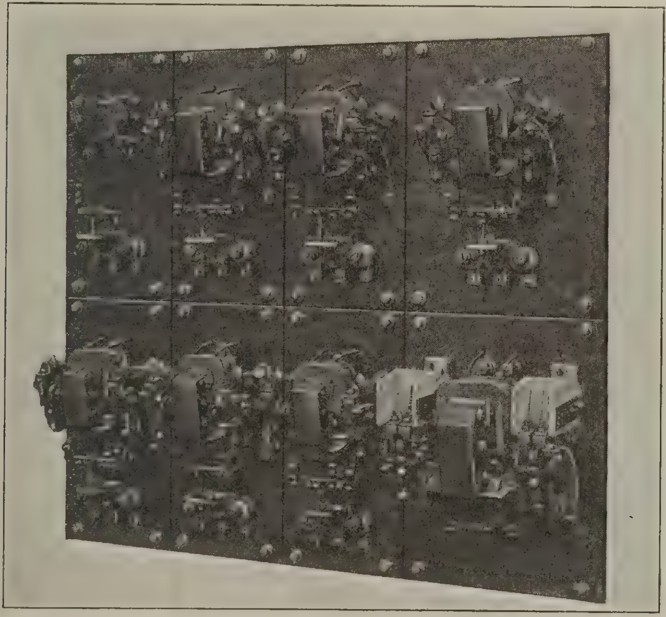


Fig. 13—Secondary Controller for Wound Rotor Induction Motor, Using Three Phase Secondary Current Limit Accelerating Relays

The amount of secondary resistance supplied with this controller may be sufficient to limit the motor current even though the motor be plugged. The torque developed by the motor with this high secondary resistance may be insufficient to start a heavy load. Under such a condition the current limit relays would not permit reduction of the secondary resistance. A so called "maximum torque button," not shown, is then supplied to by-pass the series relays and close accelerating contactor *No. 3*, thus reducing the secondary resistance to such a value that the motor will develop approximately its maximum torque.

Current limit acceleration is obtained in the above controller through use of series relays in the secondary circuit. This arrangement has merit in affording simplicity in wiring. It is also of advantage to the manufacturer in that the secondary circuits of a line of motors are usually identical, although the primaries may be wound for different voltages. On the other hand, the frequency in the secondary circuit is variable and, at high motor speeds, is very low. As a result there may be a tendency for the series relay to chatter. To avoid this condition a line of control based on the use of three phase secondary series relays is built. A secondary control panel based on this principle is illustrated in Fig. 13. The connections are shown in Fig. 14. This panel comprises a relay and seven accelerating contactors. The relay and six of the accelerating contactors are provided with three phase secondary current limit accelerating relays. The primary switching is handled separately by an oil switch or other equipment not shown in Fig. 13.

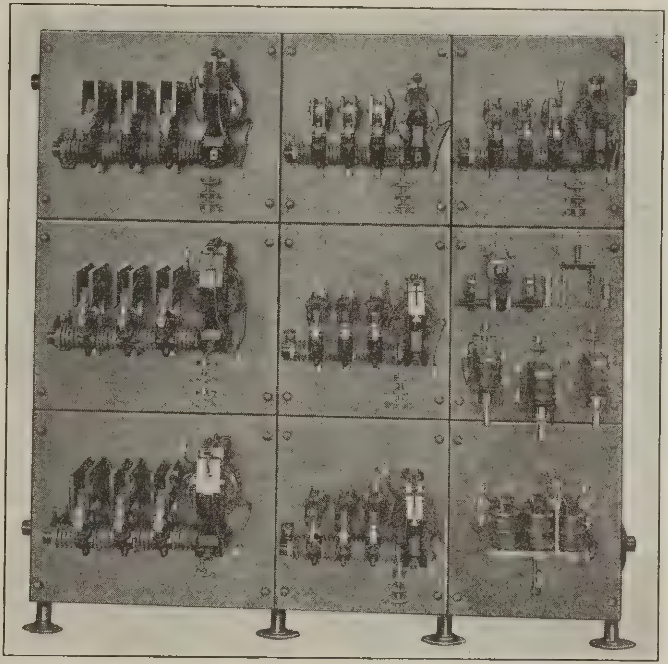
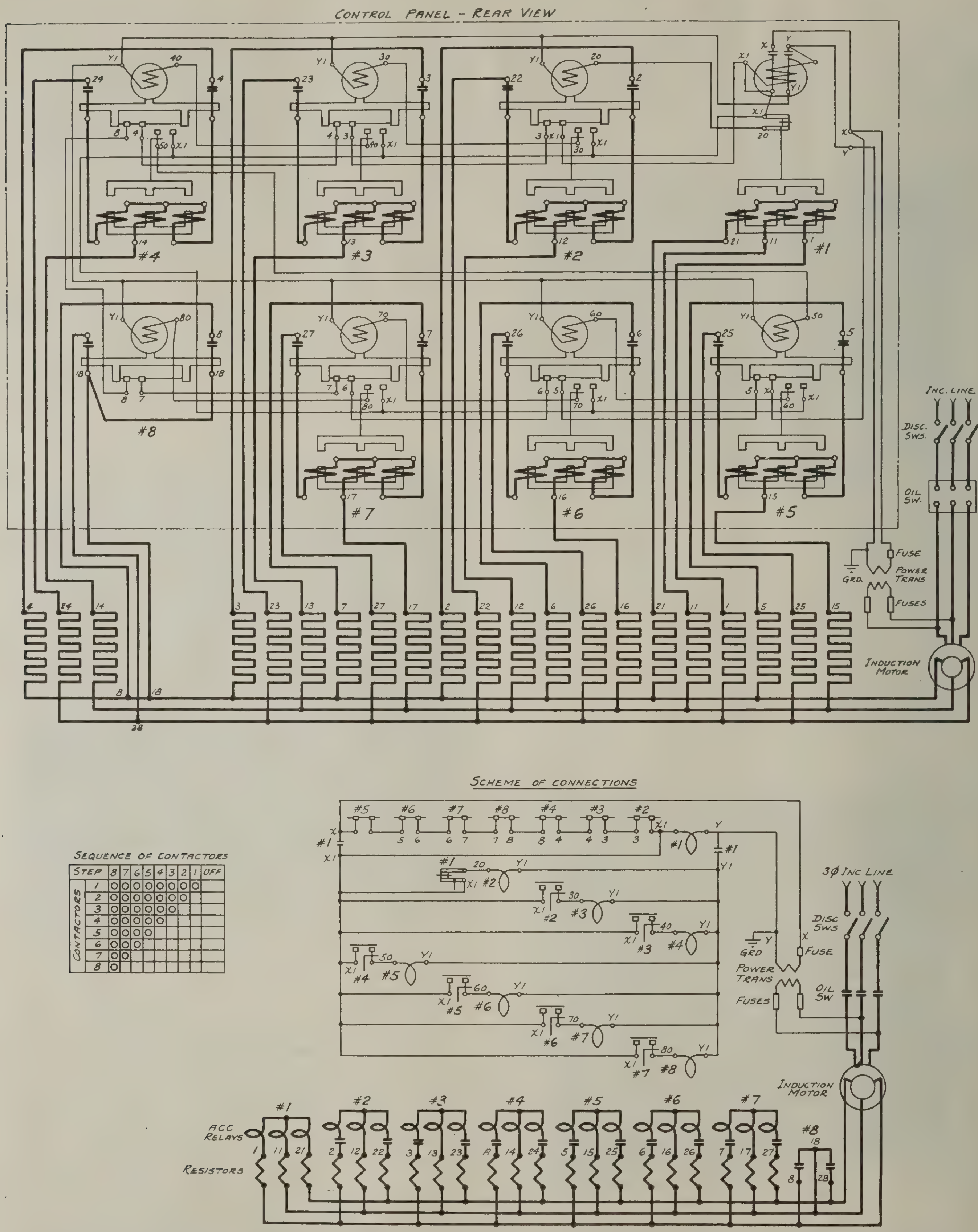


Fig. 14—Control for Wound Rotor Induction Motor, Employing "Notch Back" Relay

When the primary switch is opened all the secondary contactors open as their energizing current is taken through a potential transformer connected inside the motor primary switch. When the primary switch is closed the motor starts with secondary resistance *1-11-21* in circuit, the wye being completed at the secondary series relay *No. 1*. The rush of starting current attracts the armature of this relay, thus holding open the circuit to



SEQUENCE OF CONTACTORS

STEP		8	7	6	5	4	3	2	1	OFF
CONTACTORS	1	○	○	○	○	○	○	○	○	
	2	○	○	○	○	○	○	○		
	3	○	○	○	○	○	○			
	4	○	○	○	○	○				
	5	○	○	○	○					
	6	○	○	○						
	7	○	○							
	8	○								

Fig. 15—Wiring Diagram of a Magnetic Secondary Control For Wound Rotor Induction Motor Using Three-Phase Secondary Current Relays

the closing coil of *No. 2* accelerating contactor. When the current in the series relay *No. 1* falls off sufficiently its armature is released. The closing coil of *No. 2* accelerating relay is then energized, causing this relay to close. Resistance *2-12-22* is now connected in parallel with resistance *1-11-21*, decreasing the secondary resistance and causing the motor to speed up. Series relay *No. 2* is brought into circuit to complete the wye for this bank

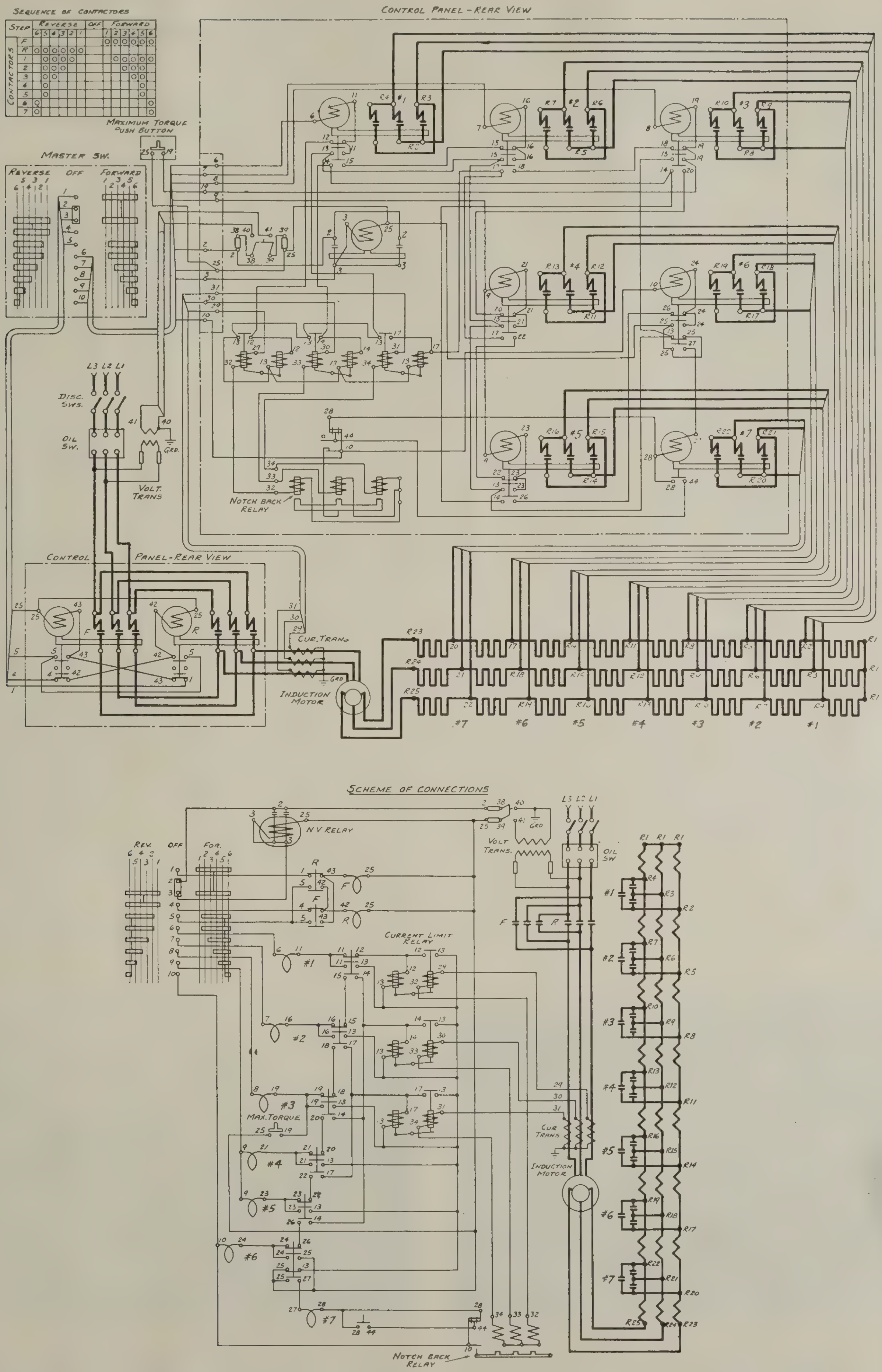


Fig. 16—Wiring Diagram of a Control for Wound Rotor Induction Motor Employing "Notch Back" Relay

of resistance. This relay functions, similarly to its predecessor, in closing accelerating contactor *No. 3*.

In like manner the remaining accelerating contactors close in sequence, each governed by the series relay of the preceding contactor. Interlocks are provided so that the voltage relay *No. 1* cannot close in starting unless all accelerating contactors are open. This is accomplished by carrying the closing circuit for this relay through auxiliary contacts on all accelerating contactors in series. These contacts are closed only when the accelerating contactors are open. This arrangement safeguards against false starting with any of the accelerating contactors closed. A further interlock is provided to insure the operation of the accelerating contactors in the desired sequence. This is done by carrying the closing circuit for each accelerating contactor through an auxiliary contact on the preceding contactor. This auxiliary contact is closed only if the preceding contactor is closed and its series relay released. The series relay functions to hold open one of the fingers making this auxiliary contact.

A magnetic controller for a wound rotor induction motor, having a number of points of interest, is shown in Fig. 15, the diagram being given in Fig. 16. An oil switch is provided in the primary circuit for overload protection. This is followed by a pair of three pole primary contactors for reversal of rotation. For this particular application, the forward contactor is normally used, the reverse contactor being used for occasional plugging only, to give a quick stop. The oil switch and primary contactors are not shown in the picture, Fig. 15. As this control is for a large motor, there are several secondary accelerating contactors. These function through the action of primary current limit relays similarly to the more simple control shown in Fig. 10. It is to be noted, however, that the current coils of these relays are energized from current transformers due to the high primary voltage. A so called "notch back" relay is supplied with this control. Its coils are energized from the current transformers in the primary circuit. When the primary current exceeds a fixed value the notch back relay opens. This, in turn, opens the last accelerating contactor *No. 7*. A step of resistance is thus inserted in the secondary circuit, causing the motor to slow down. This control is used for motors equipped with flywheels to permit the flywheels to shoulder the peak loads exceeding the value at which the notch back relay opens.

Lighting for Locomotive Terminals*

By G. W. Rink

Assistant Superintendent of Motive Power, Central Railroad of New Jersey

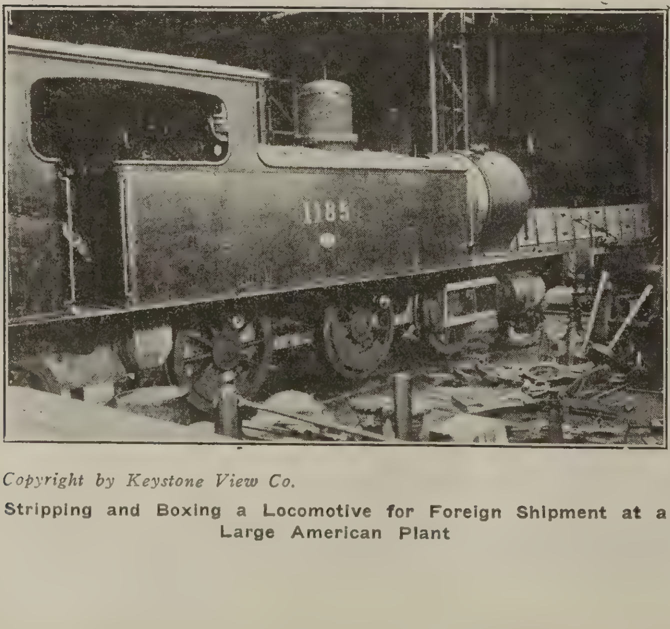
Adequate daylight facilities through large window areas, together with light, cheerful surroundings are highly desirable. The windows should be spaced and located so that daylight conditions are fairly uniform. They should also provide sufficient daylight so that artificial light will be required only during these portions of the day when it would naturally be considered necessary. Good natural and artificial light will reduce accident, provide greater accuracy in workmanship and simplify the supervision of the men.

Much needed improvement is desired in connection with artificial lighting of engine terminals. In the roundhouse proper, lights mounted on the outer wall and reflected between engine shifts have given satisfactory results when augmented by sufficient light suspended from the ceiling to afford general illumination. Machine shops, etc., should be provided with a general or overhead lighting and also supplemented by individual lamps conveniently placed, preferably on brackets so that they may be adjusted.

For lighting the roundhouse circle, flood lights should be used whenever possible as general illumination will add considerably to the safe movement of locomotives to and from turntable and engine house. Ash pits can be illuminated by rows of reflector lights placed on poles, and similar provision should be made at other points beyond turntable or by the use of flood lights on the top of coaling station. The introduction of many new types of lamps has made it possible to provide better illumination when changing from an old to a new lighting system. A study should be made of the conditions and proper lamps selected for the purpose.

---

* These are the remarks on lighting presented with a paper on Modernizing Locomotive Terminals at the annual meeting of the American Society of Mechanical Engineers, New York, December 8, 1920.



Copyright by Keystone View Co.

Stripping and Boxing a Locomotive for Foreign Shipment at a Large American Plant

Copyright by Keystone View Co.

Scene of an Accident on a French Railway at Houilles, Near Paris

Basis for Comparing Locomotive Maintenance Costs*

It Is Suggested That the Kilowatt Hour Input Is the Most Logical and Practical Unit to Use

By Hugh Pattison
Heavy Traction Dept., Westinghouse Elec. & Mfg. Co.

To all who are interested in the economical operation of electric railways, the cost of repairs to the locomotives and cars is of importance. Those charged with maintaining such equipment may be much helped by comparing their costs with those of other roads. Here one is confronted with the insufficiency of the usual units to which these costs are reduced. Usually, information is lacking which will enable useful comparisons to be made, except in the case of roads having practically identical equipment and service conditions. There are few roads so similar in these respects as not to require allowances and adjustments before a comparison of costs is of benefit. Costs of repairs are usually reduced to a locomotive-mile, car-mile, train-mile or ton-mile basis.

The locomotive-mile or car-mile as a unit takes no account of the weight or capacity of the locomotive or car nor of the character of the service. A large heavy car with electric equipment to correspond will eventually require more repairs per mile than a lighter one; a locomotive hauling heavy loads will require more repairs per mile than one in light service. Repairs are to a great degree dependent upon the work performed and a unit which does not provide for this is not satisfactory for the purpose of comparison. Often the record of mileage is not reliable, as certain dead mileage and short movements may be omitted, in fact it would be very difficult to include all these. In some services, this kind of mileage forms a relatively important part of the whole, while in other services it may be so small as to be negligible. Nearly all locomotives are required to do some switching but the amount varies widely in different services. If the amount is small, it is not included as mileage, and is sometimes omitted even when comparatively large. If it is sufficient to justify being recorded, the switching mileage is computed on an hourly basis at the uniform rate of six miles per hour. This has been shown to be quite wide of the mark in many cases. All of this means that not only is the recorded locomotive mileage quite usually incorrect, but that the extent of the error for some services is much greater than for others.

The train-mile unit has nothing to commend its use for maintenance of equipment records. Its only value is for comparing certain transportation expenses which are more a function of the train mileage than of anything else. Obviously the train-mile, since it makes no allowance for the great variation which exists in train weights, is as useless as a unit for comparing and analyzing repair costs as is the locomotive-mile.

The ton-mile is a better unit than any of the foregoing, particularly for freight service. It is a step in the right direction for it attempts to cover the work done. However, it is lacking in several important respects. To move a ton one mile up a grade imposes heavier duty upon all parts of the equipment, with consequent greater wear and tear, than to move a ton the same distance on level track or down grade. Yet the ton-miles are the same in both cases. Also a service involving frequent stops requires more from the equipment and imposes greater stresses and heating than does express service of the same ton-mileage. Mileage is one component of this unit and the record of ton-miles can therefore not be more reliable than that of locomotive-miles which, as has already been shown, is inaccurate. In addition, the record of the tons hauled is not always accurate and still worse is usually not defined. It may be gross tons, including weight of locomotives, cars and contents; gross tons, not including weight of locomotives; net tons, or contents of cars only; or revenue tons, which are net tons exclusive of certain non-revenue loads. Perhaps, because of lack of complete information, the tonnage on a division may be prorated on the basis of the system average, and thus be very much too high or too low because of some characteristic of the division's service which differs greatly from the average of the whole system. In passenger service, it is not always made clear whether ton-miles include weight of passengers, though this does not usually introduce any great error.

The kilowatt-hour input to the locomotive or car, though seldom used, is thought to be a much more correct and convenient unit than any of those discussed. The locomotive or car is a device whose duty it is to do work and we are concerned with what it costs to maintain it in proportion to the work it does. A part of the work of the locomotive is to move itself, the balance is to draw its load. Likewise a part, and a large part, of the work of a car is to move itself and the balance is to move its load of passengers or freight. There is no convenient method of segregating this, as the ratio between the gross and net weight is constantly varying. We are hardly concerned with this distinction. The propelling and controlling apparatus, including motors, gears, rods, brakes, etc., are required to do both portions of the work and are entitled, when comparing their performance, to be credited with the whole. So it resolves itself into taking the input to the device as the proper unit by which to measure what it has done. It may be said that this is putting a premium on low efficiency; but there is little to that, as the efficiencies of cars and locomotives do not vary greatly when performing the kind of service for which they are designed. When required to perform other service in which the losses may be higher, these very losses are cause for repairs in that the heating of motors, resistances and control contribute eventually to repairs. The use of the input is therefore a just and logical unit for comparing cost of maintenance.

There are undoubtedly some items of repairs which are nearly if not quite independent of the work done. Painting for instance is more a function of time than of work done or miles run. There are a few others which probably depend principally on mileage, such as wear of pantagraph or third rail shoes, although the life of these, and still more, of the trolley wheels, is affected by the amount of current collected, that is, the work done. Even for these items, since mileage is one component of the work done, the input as a unit is not far wrong. But such items are not the major ones. Repairs to motors, control, brakes, trucks, frames, gears, pinions and even wheels and bearings are largely dependent upon the load as well as mileage, that is upon the work done. Under heavy loads all parts are continuously stressed to near their maximum and while so stressed the pounding and racking due to passing over frogs and switches results in greater wear and deterioration than when an equal mileage is made under light load.

---

*The Electric Journal, October, 1920.

Where electric locomotives are double-headed, the mileage of each locomotive is recorded. Were it the policy of the road to run these multiple-unit, calling the two units one engine, the mileage would be but half that in the former case and repairs per locomotive-mile would therefore be doubled. Yet the repairs per kilowatt-hour input would be the same either way.

It is certain that, if the cost of repairs were presented on a kilowatt-hour basis, there would not be such a great and, to some, puzzling difference as exists in the customary figures per locomotive-mile for different roads, and a better indication would be secured of the merits and suitability of the different locomotives for the work they are required to do.

It must be realized that even when reduced to the most rational unit any comparison between the cost of repairs to equipment, without allowance for different conditions surrounding its operation, is almost without value and leads to no dependable conclusion. Figures based on short intervals of time, such as the month, may be misleading because of accumulation of deferred work and the entering of delayed charges and credits. All of these are smoothed out when a longer period is taken. The average for a year should be taken, and even a longer period is preferable. The history of the equipments' operation, both during and prior to the period represented by costs under examination, should be known. Overloading, either past or current, is reflected in the costs. Careful regulation against overloading now will not prevent past abuse from affecting present repairs. The correction of defects in design or workmanship may be spread over a long period and, though the correction may be fully sufficient and such equipment as is corrected may be cheaply maintained, the cost of the correction, together with the unsatisfactory performance of the equipment not yet changed, may result, during a prolonged transition period, in an average cost even greater than before any correction was applied. The very fact that a road has run during the year with little or no trouble may indicate that the year's figures for repairs cannot safely be taken as representing what may be expected in the future. Experience has shown that certain classes of apparatus have a more or less definite period of life, after which they will fail and require repairs or renewals. If very well made and handled the time for repairing will be deferred for a longer time but, when it does come, the cost during that year will be high and will raise the average of the preceding years. Also the reverse of this condition is met with. It may be that a number of alterations are early found to be desirable and for a period of perhaps several years the repairs include the cost of alteration as well as of the continued abnormal failure of those parts not yet reached in the schedule of alteration. In such cases the costs of repairs are higher than the average will be over a period long enough to include several years' operation after alterations are completed and, therefore, should not be taken as representative of the type of equipment used.

Were it the custom to reduce the cost of repairs to the kilowatt-hour basis, we would soon be familiar with a proper figure to use for this item when estimating the cost of operation of any proposed electrification. At the time of making an estimate of this kind it is necessary to determine the energy required to perform the assumed service in order to determine the cost of power, and having this the cost of repairs could be estimated more accurately than by applying some figure to the calculated locomotive-mileage. The record of kilowatt-hours input is more easily kept than the record of locomotive or ton-mileage. Of course it requires that each unit be provided with an integrating wattmeter, but this is not now unusual and there are other good reasons for doing so. Probably the roads would continue to keep their present mileage and tonnage records for other purposes, but the suggested record would be of real value to them, both to check their own costs from time to time for different divisions or types of equipment and to compare their results with those of other roads.

An incidental advantage of this custom, which is of considerable value, is that it enables the shopman to know promptly the kilowatt-hour record of any unit. Now, it is very difficult and often impossible for him to keep the mileage record of any piece of the equipment which may from time to time be changed from one car or locomotive to another. The mileage record at best only applies to the main unit, the car or locomotive as a whole, and the mileage of certain trucks, motors, axles or wheels is very difficult to follow. Were it only necessary to read the wattmeter at the time of making each change the record would be comparatively simple.

There can be no question that, with proper but moderate attention to the instruments, the wattmeter record would be more accurate than the present mileage records, and would include all work done by the unit, whether light or loaded, revenue or deadhead, switching or road. It would add no appreciable burden to the crew or clerical force to keep this record, no important expense to provide and maintain the instruments. It would aid in keeping shop records and, above all, would give a basis for intelligent comparison of different equipments which is not afforded by the present methods.

A SURVEY OF THE TRANSPORTATION FACILITIES of the Pittsburgh (Pa.) District is being made by the United States Department of Commerce. Inspectors of the bureau of foreign and domestic commerce of the department will study railroad facilities, inland waterways facilities, terminal costs, expense of loading and unloading, river transportation cost, etc. Col. James F. Bell, United States engineer in charge of the Pittsburgh district, is accompanying the government inspectors.

Principles of Car Lighting by Electricity

A Course of Practical Lessons Explaining the Main Details of This Important Application

By Chas. W. T. Stuart

IV.—Train Lighting Batteries

WE speak of the *straight storage* system, the *head end* system, and the *axle generator* system with little regard as to the importance of the storage battery, which is, indeed, a very essential part of each system.

Car lighting by electricity would not be the success that it is today were it not for the existence of the storage battery. This is true because the storage battery is the only means of storing electric power. The straight storage system has the battery as its only source of electric supply. This system is completely disabled when the storage battery fails.

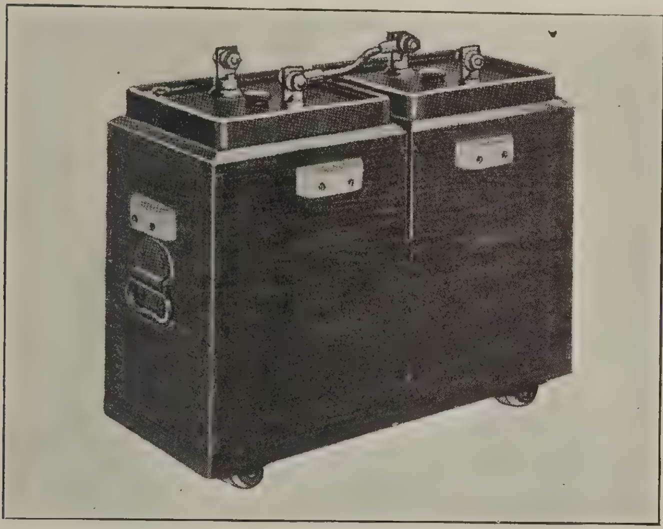


Fig. 1—Two-Cell Unit of a Lead-Lead Type Battery With Closed Wooden Tank and Rubber Jars

The head end system, when equipped with a storage battery of sufficient capacity to carry the lamp load for a reasonable length of time, will survive a turbine or generator failure en route. The axle generator system quite often survives the loss of a generator belt, a defective generator or generator regulator, without the knowledge of the train crew or any inconvenience to the passengers. The storage battery steps in and furnishes the electricity to light the car the instant the generator fails. But, should the storage battery fail, the car will be thrown into darkness the moment the train stops. When the car is again in motion, the generator will not build up unless it is provided with residual magnetism in the pole pieces. The generator furnished with some axle lighting equipments is excited by the storage battery through a unit of high resistance.

Train lighting batteries are designed to operate and give service under railroad conditions. This means that the battery must withstand rough handling, due to the bumping of the cars, etc., that it must stand a wide range of temperature due to climatic conditions, and also, be able to overcome an unlimited amount of neglect, such as remaining in a discharged condition for long periods.

The word "storage" suggests that electricity is stored in the battery, but this is not so. A chemical change occurs in the battery which under the proper conditions can be reversed to produce electricity. There are two distinct types of train lighting batteries—the *lead-lead* type battery, and the *nickel-iron or Edison* battery. In describing each type the same general outline will be used so that the reader may make a direct comparison.

Lead-Lead Train Lighting Batteries

A lead-lead train lighting battery is a number of cells each of which is a unit consisting of the following main parts:

1. Containing vessel with cover.
2. Positive and negative groups of plates.
3. Electrolyte.
4. Separators.
5. Connectors.

Various Types of Containing Vessels

The containing vessel in general use is a two compartment tank, resting on porcelain rollers or buffers. There are three general types of these two compartment tanks:

1. The closed wooden tank and rubber jars.
2. The closed wooden tank and lead linings.
3. The slatted wooden crate and lead linings.

The containing vessel for the two cell unit type as shown in Fig. 1, is a double compartment oak tank, resting on four porcelain rollers and having a wooden partition separating the two compartments. A rubber jar, shown in Fig. 2, is placed in each compartment and the space between the jars and the oak tank is filled with a low melting insulating compound. The oak tank is provided with porcelain side and end buffers. The buffers insulate the tank from the sides of the battery box and from each other.

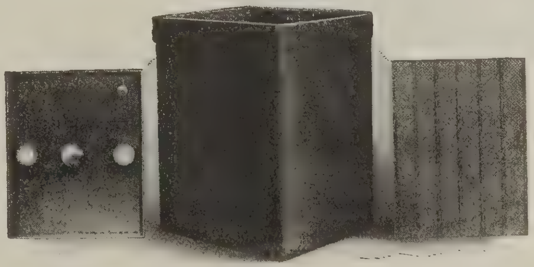


Fig. 2—Rubber Jar With Soft Rubber Cover and Double Ribbed Rubber Separator

The containing vessel for the two cell unit type, as shown in Fig. 3, is a double compartment wooden tank, resting on four porcelain buffers, and having a wooden partition separating the two compartments. A lead lining, Fig. 4, is placed in each compartment and the space between the lead lining and the wooden tank is filled with insulating compound. This compound protects the lead lining against pitting from electrolytic action, and facilitates the removal of the lining from the tank. The wooden tank is provided with wooden side and end buffers. These buffers insulate the tanks from the sides of the battery box and from each other.

The containing vessel for the two cell unit type, as shown in Fig. 5, is a double compartment wooden crate, resting on four porcelain buffers, and having a wooden partition separating the two compartments. A lead lining, as shown in Fig. 4, is placed in each compartment and tar sheets are placed between the lead lining and the wooden crate.

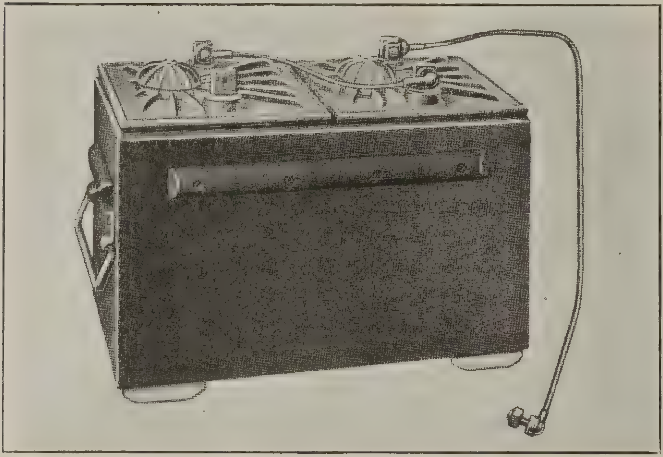


Fig. 3—Two-Cell Unit of a Lead-Lead Type Battery With Tank Crate and Lead Lining

Porcelain bottom-rests as shown in Fig. 4 are designed to support the positive and negative groups a sufficient height from the bottom of the cell to allow for any sediment that may accumulate.

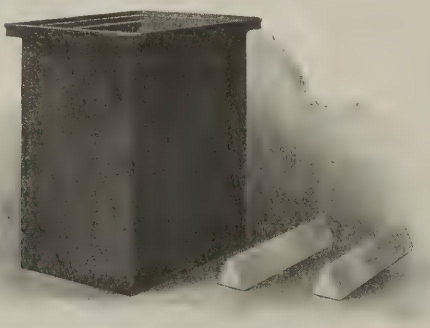


Fig. 4—Lead Lining With Porcelain Rests

The containing vessel covers are generally made of soft rubber as shown in Fig. 2, or of lead, as shown in Fig. 6. The space between the rubber cover and the rubber jar or lead lining is filled with sealing compound to hold the cover in position and to prevent the leakage of electrolyte. The lead covers of some of the containers are lead burned to the lead lining. The space around each terminal is sealed by slipping a soft rubber bushing over the terminal, and pressing it tightly into the hole in the cover. These spaces must be securely sealed, otherwise the tanks would soon become acid-soaked and grounded, and acid spray would corrode the exposed metal parts of the battery box. The use of rubber bushings also serves to reduce the breakage of covers. Each cover is provided with a vent plug to allow the gases to escape while the battery is charging. By removing this vent plug the electrolyte may be inspected and the height and specific gravity corrected.

Positive and Negative Groups of Plates

In the lead-lead storage battery both positive and negative plates are of lead. Two types of lead plates are in general use—the *Planté,* in which the active material is formed from the plate itself, and the *Faure,* in which a lead compound, transformed during the manufacture of the battery into active material, is pasted on the plate.

The Faure type of plate is seldom used in car lighting service.

The capacity of storage batteries depends upon the amount of active material exposed to the action of the electrolyte. It is advisable to make the active material in a thin layer and obtain the volume required by increasing the surface or area. There are several reasons for this, but it is chiefly due to the fact that the porosity of the material of the positive plate is insufficient to contain enough of the sulphuric acid of the electrolyte to thoroughly discharge the plate, therefore the deficiency must be supplied by diffusion, which takes place slowly. To obtain a given capacity with a thin layer of active material it is evident that the surface exposed to the action of the electrolyte must be large. For these reasons the plates are cast of cellular construction, or corrugated, grooved, or ribbed on the surface for the purpose of increasing the superficial area and so increasing the amount of active material in contact with the electrolyte. See Fig. 7.

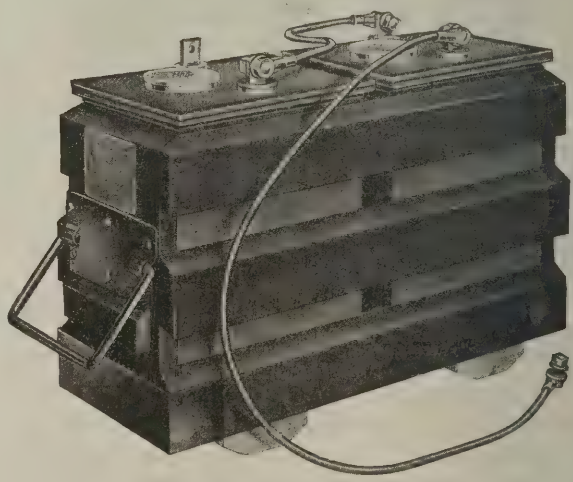


Fig. 5—Two-Cell Unit of a Lead-Lead Type Battery With Slatted Crate and Lead Lining

The life of the battery depends upon the amount of reserve lead available in the plate structure which may be converted into active material as the original active material is lost by shedding. Now, assuming that several plates of the same type have the same weight of lead, it is plain that the plate with the greatest area will also have the least thickness of reserve lead per lamination, that is, increasing the number of laminations decreases their thickness. The design of the battery plate as manufactured is therefore a comparison between these conflicting conditions and is also affected by the amount of local action, charging rates, etc.

Method of Forming the Plates

The plates having been designed to give the desired amount of superficial area, they must now be electrochemically formed to produce the desired depth of active material on their surfaces. The plates are submerged in a dilute solution of sulphuric acid to which is added a small amount of nitric acid or other forming solution. Plain sheets of pure lead known as "dummies" are placed on each side of the plates to be formed and a current from an external source passed through the solution from the plates to the dummies.

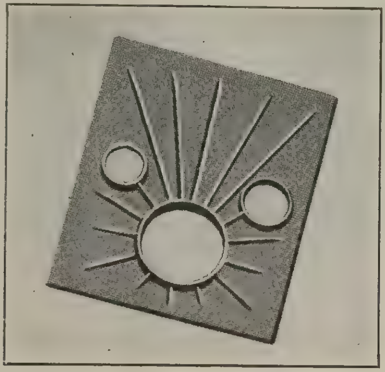


Fig. 6—Lead Cover

The surfaces of the plates, under the combined action of the forming solution and the current, are changed from lead to a mixture of lead sulphate and lead peroxide, this operation being known as "forming," and this mixture of lead sulphate and lead peroxide at this stage being known as the "formation."

The forming may be carried on until any desired depth of active material is obtained, while the hardness of the formation can be varied, by varying the rate of current flow and the density of the forming solution. This process converts all the plates into positives, but, on such as are intended for negatives, the formation is carried to a greater degree.

After being formed, the plates intended for negatives are placed in tanks containing dilute sulphuric acid, with dummies on each side of the plate, as before, and current from an external source is passed from the dummies to the plates. The lead peroxide on the plate, under the action of the current, is converted into spongy lead, or in other words, the plate is converted into a negative.

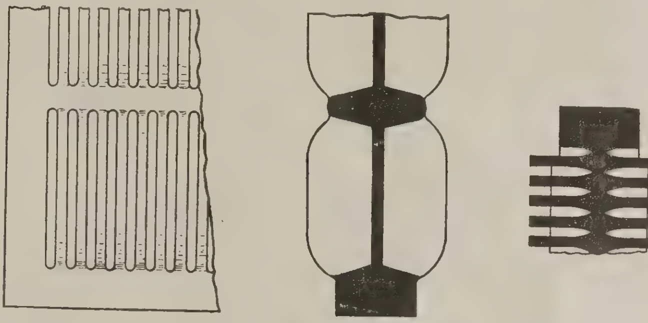
The plates usually stand for some time in the stock room before being burned to their respective cross straps or bridges and become more or less dried out. Consequently, after the plates are burned to the cross straps, set up with separators, and placed in the tanks, they must be very thoroughly charged to reduce the lead sub-oxide into which the spongy lead has been converted and to thoroughly develop the positive plates.

Elements in the Lead-Lead Cell

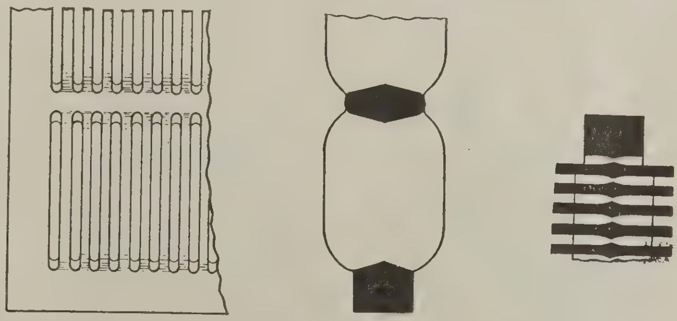
The *positive* group, as shown in Fig. 8, is made up of a number of positive plates burned to a connecting strap or bridge. The Planté type of positive plate consists essentially of lead which has been treated by some mechanical process to greatly increase its superficial area. Its surface has been converted, by chemical or electrochemical means, into lead peroxide. This lead peroxide has a rich chocolate brown color when the battery is fully charged. The body of the lead serves as a support for the lead peroxide or active material, as a conductor for the current, and as reserve material to be converted into lead peroxide when the original active material is lost by shedding and falling to the bottom of the containing vessel.

The *negative* group, as shown in Fig. 8, consists of a number of negative plates burned to a connecting strap or bridge. The negative group always has one plate more than the positive group with which it is used. The negative plate is similarly treated to increase its superficial area and the surface is converted into active material. The active material in this case is spongy lead or lead which is very porous. The spongy lead has a slate gray color when the battery is fully charged.

The *separators,* Fig. 9, may be made of any insulating material which prevents the negative and positive plates from coming into electrical or mechanical contact, but which does not prevent the electrolyte from reaching the plates. Furthermore, it must not be affected by the electrolyte or contain substances injurious to the battery. Hard rubber is generally used for this purpose in the batteries for electrically lighted cars and is made up in the form of a thin sheet having numerous small perforations with several ribs extending across the sheet to strengthen it and at the same time to give the necessary separation between adjacent plates.



"H" STRUCTURE EMPLOYED IN NATIONAL POSITIVE



"U" CELLULAR STRUCTURE EMPLOYED IN NATIONAL OPEN NEGATIVE

Fig. 7—Showing One Method of Construction By Which the Plate Surface is Increased

The *electrolyte,* or solution in which the groups are submerged in a containing vessel, consists of dilute sulphuric acid of a normal specific gravity of 1.220 at 70 degrees F., when the battery is fully charged. (The specific gravity of a liquid is the weight of that liquid divided by the weight of an equal volume of water.)

The two cells in the tank are connected together, positive to negative, by means of insulated copper wire. The terminals of adjacent tanks are also connected together by insulated wire connectors.

A Few Points on the Theory of a Lead-Lead Storage Battery

As it is chemical energy that is stored in the battery and not electricity, it is necessary when explaining the action that takes place in the battery to include chemical symbols, formulas and equations. Therefore an explanation of a few terms may help those who have no knowledge of chemistry. The symbols for the elements which will be used are as follows:

Elements	Symbols
Hydrogen	H
Oxygen	O
Sulphur	S
Lead	Pb.

These elements are combined into the following: Water, sulphuric acid, lead sulphate, lead peroxide.

The formula for water is H_2O, meaning that hydrogen and oxygen are combined to form water.

The formula for sulphuric acid is H_2SO_4 meaning that hydrogen, sulphur and oxygen are combined to form sulphuric acid.

$PbSO_4$ is the formula for lead sulphate, indicating a combination of lead, sulphur, and oxygen.

Similarly PbO_2 signifies that lead and oxygen are combined to form lead peroxide.

Action of Discharge

On discharge the spongy lead (Pb) and lead peroxide (PbO_2) are converted into lead sulphate ($PbSO_4$) at the expense of some of the sulphuric acid (H_2SO_4) and in an amount almost exactly proportional to the ampere hours discharge; while in addition some water (H_2O) is formed, which dilutes and decreases the specific gravity of the electrolyte.

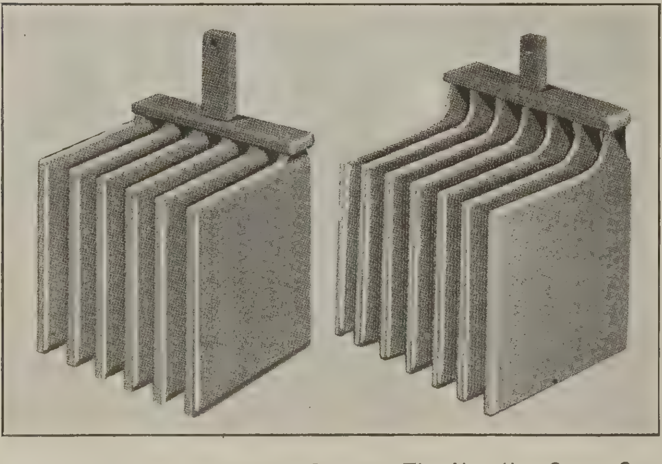


Fig. 8—Positive and Negative Groups. The Negative Group Contains One More Plate Than the Positive

The original chemical energy is decreased by an amount equal to the electrical and heat energies developed, the latter being relatively small.

Action on Charge

On charge the reverse action takes place, the lead sulphate ($PbSO_4$), previously formed on discharge being converted back to spongy lead (Pb) in the negative plates, and to lead peroxide (PbO_2) in the positive plates, a certain amount of water being chemically combined, in again forming the sulphuric acid (H_2SO_4) and lead peroxide (PbO_2).

The lead storage battery therefore belongs to that class of batteries which are more or less reversible in their action. It is not completely reversible because of the heat generated and because of other actions described below.

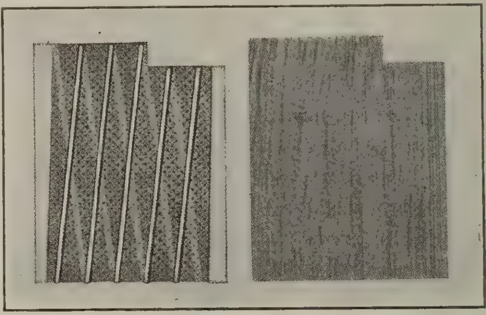


Fig. 9—Separators

The chemical reactions taking place may be expressed by the following equations:

Reaction at positive plate:

(a) $PbO_2 + H_2SO_4 = PbSO_4 + H_2O + O$

Reaction at negative plate:

(b) $Pb + H_2SO_4 = PbSO_4 + 2H.$

Combined Reaction of positive and negative plates:

(c) $PbO_2 + Pb + 2H_2SO_4 = 2PbSO_4 + 2H_2O.$

These equations are the fundamental equations of the lead storage battery.

Equation (c), read from left to right, is the equation of discharge, and shows the change of spongy lead and lead peroxide on the negative and positive plates respectively into lead sulphate and the formation of water from the hydrogen and oxygen of the electrolyte. Read from right to left this equation shows the reaction during charge.

The Active Materials of a Lead Cell

It is to be noted that the active materials are not hard dense masses, but are crystalline in structure, as will be readily apparent under a moderately strong magnifying glass. The crystals are more or less intermeshed, so that the masses are coherent. The chemical changes above described do not take place completely throughout the crystals, but the action is more or less confined to their surfaces. Both the spongy lead and the lead peroxide crystals are electrical conductors, and the active masses are conductors because of the contacts of these crystals. The lead sulphate formed on discharge is, however, non-conducting. It is probably oxidized at the positive and reduced at the negative on charge, because of its solubility, though the degree of solubility is very slight. The difference between the lead sulphate normally formed on the discharge of a battery and the injurious sulphate which is sometimes evident, probably lies in the fact that the normal sulphate is composed of extremely minute crystals and is therefore more readily soluble while the injurious sulphate is composed of relatively large crystals, and therefore soluble with difficulty. This injurious sulphate may be reduced to spongy lead by excessive charge, but is with difficulty or not at all to be directly oxidized to lead peroxide.

The tendency for small crystals to merge into larger ones, which is plainly seen in a saturated solution of copper sulphate, is an explanation of the manner in which the injurious sulphate is formed. This is one of the reasons why storage batteries should not be allowed to stand wholly or partly discharged for longer periods than is absolutely necessary under the service requirements.

It has been pointed out that the active materials are crystalline. The dilute sulphuric acid electrolyte fills the spaces between the crystals, that is the pores of the masses of active material. The porosity of the active masses is fairly high but varies with the method of formation. In practically no case is it great enough, however, to accommodate sufficient sulphuric acid for the complete conversion of the active materials. The deficiency of acid has to diffuse into these pores from the outside. The phenomenon of diffusion, as distinguished from convection, is extremely slow, and for this reason the practical thickness of the masses of active materials used is limited; a greater thickness is permissible for low discharge rates, as a longer time is then available for fresh acid to diffuse into the pores of the mass of the active material. Diffusion is greatly accelerated by increased temperature; for this reason high temperatures increase the discharge capacity. Very high temperatures, however, are not permissible, as a corrosion of the positives is more rapid.

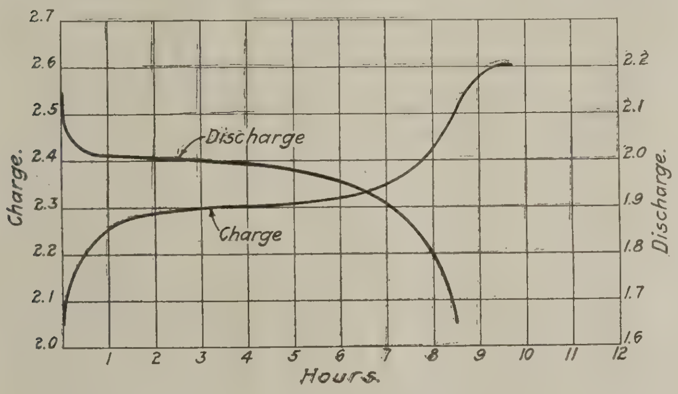


Fig. 10—Charge and Discharge Curves—Eight Hour Rate

The Limit of Discharge

The limit of discharge capacity is largely set by the porosity of the active materials and the rapidity of diffusion of the acid into its pores. The extent of the conversion of the active materials into lead sulphate must also be limited as the electrical resistance increases considerably at the latter end of discharge.

Approximately, only thirty to fifty per cent of the entire amount of active material takes part in the reaction for the above reasons.

Difference Between the Electro-Motive Force and the Voltage at Terminals

The electro-motive force of a lead battery as distinguished from the voltage at the battery terminals, is dependent only on the strength of the electrolyte and its temperature, as long as any unconverted active materials are present. On open circuit a battery always shows a voltage of approximately 2.1 volts. The voltage at the terminals on discharge is less than this amount by the value of the various resistance voltage drops. These resistance voltage drops are:

1. The drop in the terminal lugs and grids of the plates.
2. The drop in the current path of the active material.
3. The drop in the current path in the electrolyte, both in the pores of the active material and outside of the plate.

If the battery is partly discharged, the open circuit voltage, immediately after interrupting the current, is somewhat lower than the value given above, but it readily approximates this value as acid diffuses into the plates. For this reason open circuit readings are of no value in determining the state of charge of a battery. It has been shown that on discharge the voltmeter reading is the battery electro-motive force less the sum of the various resistance voltage drops.

On charge, the various resistance drops are still present, but must be added to the electro-motive force of the cell to give the impressed terminal voltage, that is, the voltmeter reading. This explains in part the difference of voltmeter readings obtained on charge and discharge. Fig. 10 shows charge and discharge curves of a lead battery when charged and discharged at the normal rate.

The lead sulphate formed on discharge occupies a greater volume than either the spongy lead or the lead peroxide, from which it is formed. In consequence there is an expansion of the active material which must be taken up either in its pores or by the grid. This must be cared for in the design of the plates as far as it is possible, and in service the battery should not be overdischarged if it can be avoided. Too great an expansion from the above cause results in growth and buckling of soft lead Planté plates or the breaking of the grids of pasted plates.

Sediment, or Shedding of Active Material

The small lead crystals of the negative active material show a decided tendency to cohere and negative plates do not shed much active material unless considerably sulphated. The crystals of lead peroxide of the positive active material, however, are hard, and are not as coherent as those composing the negative material. These lead peroxide crystals gradually break up into small crystals with successive discharges, and finally become so small that they have no coherence. Gassing of the plates on overcharge dislodges such crystals, and these, together with any loose crystals of sulphate which may have formed, constitute the sediment or battery "mud" in the bottom of the tank. Excessive overcharge, in ampere hours, especially at high rates, is to be avoided for the above reasons. A limited amount of overcharge, however, is necessary to keep the plates in good condition. Also a certain amount of sediment is normally to be expected, but good operation will ensure that it is a minimum. All of these statements hold true whether the plates be of the Planté or of the pasted type. The pasted plates are characterized by having relatively large masses of active materials, with a small amount of lead grid surface, while with Planté plates there are relatively small masses of active material with lead underlying them, the developed area of the lead being great.

In the action of the batteries with the Planté plates there is a normal slow corrosion of this lead, forming new active material. The capacity of these plates may diminish, remain normal, or even increase, as long as there is reserve lead in the plates, according as this reserve lead is corroded and converted into active material at a lower, the same, or at a greater rate than that at which the original active material sheds off.

As the active material on a pasted plate sheds off during its life, the capacity diminishes as the plates age, because there is no reserve lead to be converted into new active material to take the place of that shed.

Reason for the Growth of Plates

As the lead sulphate and lead peroxide that is formed, cohere with the lead and occupy a greater volume than the original lead, there is a tendency for the plate to stretch or grow, principally in the length direction of the ribs.

Unequal corrosion on the two sides of the plate, will result in an unequal growth of the two sides and cause the plate to warp or buckle. The conditions at the negative plate are such that there is normally no such corrosion; therefore no growth or buckling. With the above facts in view it is plainly necessary that batteries should be so operated that the rate of corrosion of the underlying lead of the positive plates is kept within bounds.

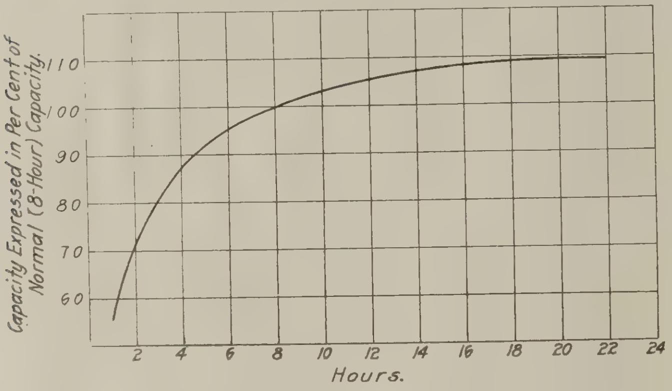


Fig. 11—Variation of Capacity With Varying Rates of Discharge

New active material should be formed at about the same rate as the old active material falls off in the form of sediment.

The rate of corrosion of the lead underlying the positive active material may be high, under certain conditions. These conditions are:

1. With discharged positives, the remaining lead peroxide automatically discharges into the underlying lead. A battery should not, therefore, be allowed to stand any longer than necessary in a discharged condition.

2. With low rates of charge, the chemical reactions previously described are departed from on the positives, and the current instead of wholly converting the lead sulphate previously formed on discharge, into lead peroxide, accomplishes this only partially and in addition corrodes some of the underlying reserve lead to lead sulphate.

3. Violent corrosion of positive plates may occur if traces of acids or acid forming substances other than sulphuric acid are allowed to get into the electrolyte.

As mentioned above (2) low charging rates (rates less than eight hour rates) are to be avoided, especially if the battery is in a discharged condition. Either of the effects mentioned in (1) and (2) are usually relatively slow, but may under certain conditions be greatly accelerated, for example, high temperature and weak electrolyte.

Ampere Hour Capacity of a Lead Battery

The rated capacity of a battery is the normal discharge rate in amperes, times eight hours, and the battery is considered completely discharged when the potential difference at the terminals falls to 1.8 volts per cell, with the battery discharging at normal rate and the normal temperature.

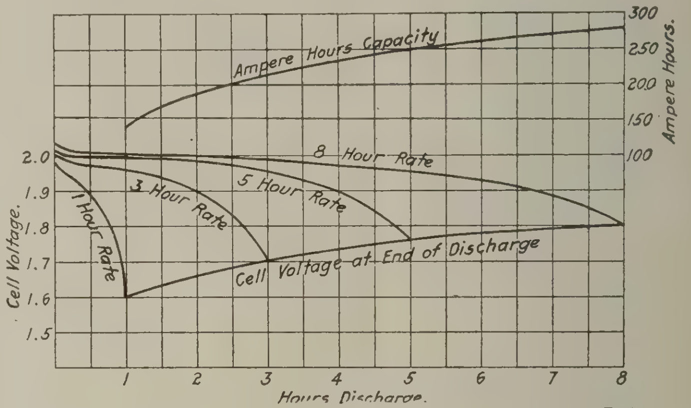


Fig. 12—Variation of Capacity With Various Discharge Rates

The capacity varies with the rate of discharge, being less at high than at low rates, principally on account of the less time for acid diffusion. Fig. 11 gives a curve showing the variation of capacity with various rates of discharge expressed in per cent of the eight hour capacity.

The variation of capacity at various discharge rates and the corresponding terminal voltage for each rate is shown in Fig. 12.

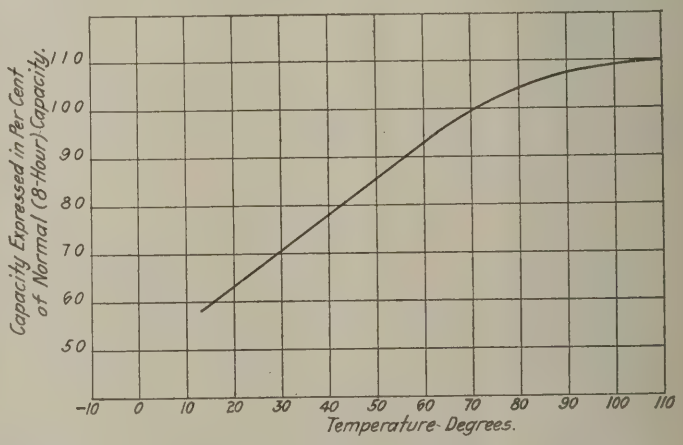


Fig. 13—Variation of Capacity With Variation of Temperature

The capacity of a battery also varies with the variation of the temperature above or below normal, which is 70 degrees F. Fig. 13 shows a variation of capacity with variation of temperature.

Method of Maintaining the Capacity

The maintenance of the voltage and consequently the capacity of the battery, depends upon both the positive and the negative plates. Therefore, if the plates of either positive or negative groups be lacking in capacity, either on account of being deficient in active material, or on account of being only partially charged, or for any other reason, the capacity of the battery as a whole is only approximately equal to that of the group having the least capacity. It is therefore necessary that both positive and negative plates be fully charged and that they both have a sufficient quantity of active material.

The voltage reading of the battery is not an absolute indication of the condition of the plates and to determine the condition and the capacity of the positive and negative plates it is necessary to test each plate independently.

This test is made by immersing a piece of metal, known as cadmium, in the electrolyte, while the battery is on discharge and observing the voltage between it and the positive and negative groups. The cadmiun test will be included in detail in a later lesson.

The Future Transportation of Greater New York*

Tremendous Growth of Population Will Cause Revolutionary Changes in Present Traffic Facilities

In order to visualize and discuss a subject of such magnitude in a limited time, it will be necessary to confine our consideration to the larger outstanding features of the problem. It will also be helpful to brush aside detail and attempt to grapple in the large with underlying principles. Let us therefore first free our minds of our habitual ideas of New York as Manhattan Island and think rather of the great surrounding district extending even outside of the five boroughs of Greater New York.

From a Transportation Standpoint, What Is Metropolitan New York?

In 1820, one hundred years ago, New York meant lower Manhattan Island south of a line following Greenwich, Eighth and Houston streets. The population was then 123,000 and Brooklyn Village had 11,000 people.

In 1870, half a century later, New York was still confined to Manhattan Island but had built up solid to Fifty-ninth street and a few scattered settlements had commenced to develop further north. The population of the city was then 942,000 and Brooklyn had grown to a city of 420,000 people.

Today (1920) we find the New York of fifty years ago extended north to Spuyten Duyvil creek covering the whole of Manhattan Island from north to south and from river to river with commercial or residential structures. The population of Manhattan New York by the 1920 United States census is 2,284,103.

Closer scrutiny discloses the fact that two important changes have occurred, i. e. the population of Manhattan Island has reached its maximum and started to recede, having lost nearly 50,000 in the past decade, and also the old Manhattan New York as an independent self-contained city no longer exists. The New York of our fathers has overflowed into or been merged with the life of its surrounding neighbor communities.

Manhattan New York has had part of its residential population forced out and beyond its borders by the crowding in of business and others of its citizens have been tempted to move across the rivers by the improved transportation offered by its enlarged rapid transit lines.

For our purpose, it appears that we may take the New York Metropolitan District substantially as defined by the United States Census Department, which includes in New York State the five boroughs of Greater New York and Westchester county north to include Yonkers and New Rochelle. On the New Jersey side it takes in all of Bergen and Hudson counties and parts of the counties of Passaic, Essex and Union. This district is shown on the map, Fig. 1, and is outlined by a heavily shaded broken line.

Taking the intersection of 34th street and Fifth avenue of Manhattan as the urban center of activity and describing circles with five, ten, fifteen and twenty mile radii, we find that this Metropolitan district lies mostly within the fifteen mile circle and all within twenty miles of the center. The cities grouped around Manhattan New York and included in our Metropolitan area lie as far east as Flushing and Far Rockaway, Yonkers on the north and Paterson, Newark and Elizabeth to the west. Fifty years ago these latter were remote and totally unrelated communities but today the whole group with New York as a center has by a process of growth and development merged into a single metropolitan community in spite of geographical obstacles and political boundaries.

It is true that there are in this territory many entirely independent, unrelated classes of people and interests but we also find a constant growth in the commoner functions of city life. The trains, for instance, not only carry workers morning and evening from Newark to New York, but also simultaneously from homes in New York to employment in Newark.

The food markets of Manhattan supply both retailers and individuals from Flushing, Yonkers and Elizabeth, while many industries have general offices in one district and factories in another with constant travel back and forth as in a smaller city. The average population density is 21 per acre, which is the same as corporate Chicago in 1916.

The conception of this whole district as a Metropolitan unit, a single city, involves an urban and suburban traffic view in which Manhattan Island figures as the central delivery district for this larger area, with subcenters of activity in Brooklyn, Newark, Yonkers, etc., but all related to one another by the common necessity of easy, frequent passenger inter-communication.

---

*Abstract from an address by H. M. Brinckerhoff before the American Society of Civil Engineers, November 17, 1920.

Outside our central Metropolitan limits, we must visualize a further zone of strictly suburban character, contributing daily riders to and from the center but less closely tied to the city district in other respects.

Area of Metropolitan District

Looking at our map we see that the axis of Manhattan Island north and south almost exactly divides this Metropolitan district in two equal parts. In the following table are given the areas in square miles of the boroughs and counties and parts of counties included.

In each case the areas not suitable for residence such as the marshes along the Hackensack River and bordering Jamaica Bay have been omitted:

Table I—Area of Boroughs and Counties in Metropolitan District

Manhattan	22 sq. miles	14,000 acres
Brooklyn	69 sq. miles	44,000 acres
Bronx	42 sq. miles	27,000 acres
Queens	105 sq. miles	67,000 acres
Richmond	48 sq. miles	31,000 acres
Yonkers (Westchester)	47 sq. miles	30,000 acres
Total in New York	333 sq. miles	213,000 acres
Bergen County	80 sq. miles	51,000 acres
Hudson County	29 sq. miles	18,500 acres
Passaic County	29 sq. miles	18,500 acres
Essex County	53 sq. miles	34,000 acres
Union County	48 sq. miles	31,000 acres
Total in New Jersey	239 sq. miles	153,000 acres
Grand total area, Metropolitan District	572 sq. miles	366,000 acres

The division of areas between New York and New Jersey shows New York 333 square miles against New Jersey with 239 square miles. Transferring Richmond Borough to the New Jersey side as being geographically and from a transportation standpoint west of the Hudson River, and considering Manhattan Island as a passenger delivery district with the remaining territory of the Metropolitan areas as tributary, we find 263 square miles east and 287 square miles west of this central district.

Distribution and Growth of Population

Transportation requirements have a direct relation to the number of people in the area to be served and also to their distribution residentially as well as the location of their places of occupation. At least 50 per cent of the passenger traffic handled by city transportation lines consists of workers going daily from homes to places of employment and return. The tendency of population growth is important then in an analysis of the transportation needs we are considering.

Table II shows the population for one hundred years by fifty year periods, of this Metropolitan district and the densities per acre at present:

Table II—Population Distribution in Metropolitan District

	1820	1870	1920	Population per acre 1920
Manhattan	123,000	942,000	2,284,000	163
Brooklyn	11,000	420,000	2,018,000	46
Bronx	....	....	732,000	27
Queens	22,000	74,000	469,000	7
Richmond	6,000	33,000	147,000	4
Yonkers	1,600	18,000	210,000	7
Total in New York State	163,600	1,487,000	5,830,000	average 27
Bergen County	9,000	30,000	120,000	3
Hudson County	9,000	129,000	630,000	34
Passaic County	....	39,000	220,000	12
Essex County	12,000	133,000	620,000	18
Union County	....	31,000	130,000	4
Total in New Jersey	30,000	362,000	1,720,000	average 11
Total for Metropolitan area	193,600	1,849,000	7,550,000	average 21
Ratio of N. Y. to N. J.	5½ to 1	4 to 1	3½ to 1	

The important point to be noted from this table is that the ratio between the population east and west of the river has been constantly decreasing during the past one hundred years. The denser and larger population groups were originally located close to the harbor shipping development, but this characteristic is passing with the increase in manufacture and distribution of population by the rapid transit lines. The eastern or New York territory shows particularly the wider distribution and the New Jersey side in points like Newark and Paterson has been affected by the manufacturing distribution.

This means that in the past New York harbor development as a port in a general way confined the location of dense population in districts close to the shipping activities. With the rapid transit development on the New York side came the ability to live at great distances from employment centers, which then produced the rush to the Bronx, Queens and Brooklyn.

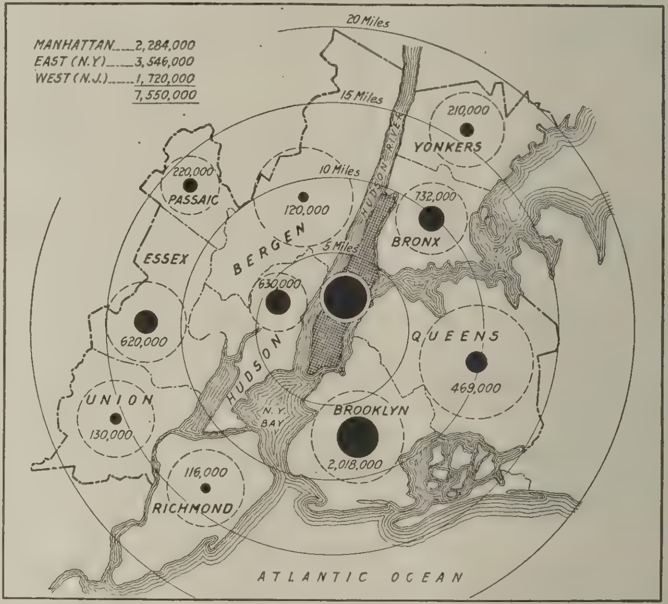


Fig. 1—Map Showing the Population Density in the Metropolitan District

The possible control over the further growth and distribution of population by the location of new or the extension of old city and suburban transportation lines hence becomes very obvious. We should, therefore, consider very seriously this subject from the broad viewpoint of Metropolitan New York when studying present needs and future city growth.

Transportation Growth in the Metropolitan District

When New York was limited to Manhattan Island, the transportation lines naturally developed north and south the long way of the city. Generally speaking, business was downtown (south) and the residence sections uptown (north).

So long as New York as a city was confined to this long narrow island, this characteristic prevailed, but when the population began to overflow and inter-business relations among the neighbor cities grew closer, a spreading-out process commenced. Brooklyn was connected by bridge and later by tubes, then the Bronx, Queens and New Jersey were reached by direct subway lines. The great dual subway system financed by the city of New York followed the north and south idea on

Manhattan Island but branched out north, east and southeast into the Bronx, Queens and Brooklyn.

We have now come to a point when further plans are placed before us by our Public Service Commission which are the result of a long period of study of the subject by the chief engineer, Mr. Turner. Hampered by the limitations of state boundaries he has followed to a logical conclusion the result of distributing further large population increases by lines built exclusively in New York State and leaving the New Jersey side to take care of its own problem.

Mr. Turner predicts that corporate New York (the five boroughs) will grow to nine million population by 1945. He finds by a further development of the idea of north and south rapid transit lines on Manhattan Island that at least 2 eight track subway lines will be required. Each of these will have two levels of four tracks in a single street. The total number of north and south subways and elevated tracks on Manhattan Island following this plan will ultimately be forty-eight. This is shown to be necessary in providing for continued distribution of population along rapid transit lines in the Bronx, Queens, Brooklyn and Richmond boroughs on these general lines.

Turning to our population charts, we see that, from the standpoint of Manhattan Island as a delivery district, sparsely settled areas are available west of the river at shorter distances than to the east which should warrant their consideration.

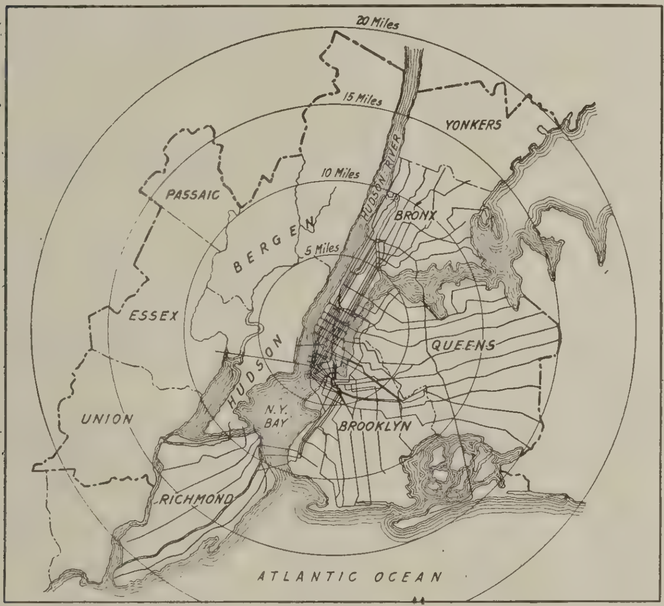


Fig. 2—Present Lines and Lines Proposed by the New York Public Service Commission

From a general economic standpoint the fact is apparent that the vital necessities for the maintenance of a great city population, food, fuel and water come to this Metropolitan district from the west and that the cost of transporting the two former from the west side of the district to Brooklyn and Queens is almost as great as the cost of hauling the same material from Pittsburgh to Newark.

This line of thought naturally leads to the suggestion that from the Metropolitan standpoint at least a portion of future population increases should be provided for west of the Hudson. This can most readily be accomplished by east and west rapid transit lines running from Queens or Brooklyn to Bergen and Hudson counties in New Jersey and passing right across Manhattan Island. This is warranted and would bring about a better distribution of population relatively to Manhattan as the center of the whole Metropolitan area.

A rectangular system with transfers at the intersections would tend to distribute the business development more evenly across Manhattan Island instead of the great local congestion which must result along the avenues from four and eight track subways built exclusively north and south. A shorter average haul to the delivery district would also be obtained and more balanced two-way traffic developed than by forcing the population growth entirely to the east.

On the accompanying chart a general suggestion for such lines is shown to convey the idea of a gridiron system in relation to the whole Metropolitan area. These east and west rapid transit tracks could be fed by the transfer from the present or new surface lines.

Metropolitan Rapid Transit Plan

The accompanying chart is intended to illustrate the general idea of east and west rapid transit lines crossing Manhattan and reaching out into the territory in both the directions.

The upper line crosses Manhattan at 125th street, penetrating the Bronx in one direction and Bergen county, N. J., in the other.

The next line utilizes the Queensboro Bridge and reaches Flushing and vicinity, while in the west, after crossing the Hudson river it crosses the southern part of Bergen county and extends to Paterson.

The third line from the north is located as an extension of the Steinway tunnel across 42nd street, then under the Hudson and west to top the territory of Bloomfield and Montclair.

A more southerly line connects with the B. R. T. Broadway elevated and runs on the Williamsburg bridge, thence across Manhattan to Jersey City to Newark and the Oranges.

The lowest line is shown running from one of the Brooklyn lines across the tip of Manhattan Island and striking Jersey at the Central Railroad of New Jersey station.

On the Jersey side is shown a north and south line reaching from some point on Staten Island under the Kill Van Kull, then by elevated through Bayonne and north probably west of Union Hill. This line is intended as a connecting and distributing line to divert as far as possible north and south transfer from Manhattan and allow of operation into and across the city from many districts.

The general idea is short trunk lines east and west with feeders from a constantly widening area.

Present Transportation Needs

More interesting to the average man than the future is the question of how he is to get to and from his work now. Having analyzed the general conditions and pointed out broad lines for thought upon the general scheme, we can turn to our own troubles of today. Upon what transit facilities are we now dependent in Metropolitan New York? In the reverse order of their importance by volume of passengers handled daily, they are as shown in Table III.

Table III—Classes of Transportation and Their Daily Traffic. New York Metropolitan District

	Per cent of total for whole Metropolitan District
Busses—	
Fifth Avenue Company and city busses	2
Ferries	5
Steam railways entering New York	4
Surface lines	35
Rapid transit, elevated and subways	54

This sub-division of traffic is peculiar to New York. In London, the rates are as follows:

	Per cent of total
Bus	33
Surface cars	27
Rapid transit	40

In Chicago, the situation is different again, the rapid transit lines being less developed:

	Per cent of total
Surface cars	73
Rapid transit	21
Steam suburban	6

Travel to Main Delivery District—Steam Railroad

The map of our Metropolitan district, Fig. 4, shows the passengers delivered to the central (Manhattan) delivery district by the "steam" railway lines from the west, north and east. In order to make the chart effective and easily read all the lines entering from the west are shown by a single band and similarly for those from the north and from the east. The width of the bands indicates the number of passengers per average week day.

Passengers Delivered to Manhattan by Steam Railway Lines on Average Week Day

From the West	167,000
From the North	57,000
From the East	74,000*
	298,000

---

*Including those delivered by the Long Island Railroad to Brooklyn and Queens.

Ferries

The total traffic carried to Manhattan by ferries from all sources is given in Table IV. The number of passengers carried by these ferries originating in the districts adjacent to the ferries or brought to them by trolley or bus lines is shown in the second column of the following tables. The attempt has been made to separate this travel from that shown as of "steam railway" origin. The various railroad companies have separated their ferry traffic for us in that manner.

Table IV—Ferry Traffic to Manhattan (One Way)

	Total	Local
From the West	142,000	67,000
From the East	29,000	29,000
From the South	30,000	30,000
	201,000	126,000

Central Delivery District

Into lower Manhattan, i. e. below 59th street, or an area of ten square miles, there is daily poured two million people. This means almost doubling the population of the island. Judging from the fact that the resident population as shown by the recent census has decreased 50,000 in the past decade, the influx of daily non-residents may be conceived of as forcing the residents off the island.

This daily inflow to lower Manhattan is equal to one-fourth of the population of the Metropolitan district, but of course a portion comes from upper Manhattan and a small number from suburban territory beyond the limits selected. With double or certainly with triple the present population this concentrated central traffic movement would mean the displacing of a large part, if not all, of the resident population of Manhattan.

A study of the rate at which this centralized traffic has increased and the fact that it had developed largely coincident with the great rapid transit development of the past twenty years is cause for careful consideration, before we adopt either the rate of increase shown or the growth of the traffic itself.

Like the tendency indicated all over the United States by the 1920 census of a concentration of population in cities the thought occurs at once that this character of central travel must have some limit. If you bring all the people of the country into cities they will starve for lack of food, and if you move more than a certain number into Manhattan daily they cannot walk about on the sidewalks, for instance.

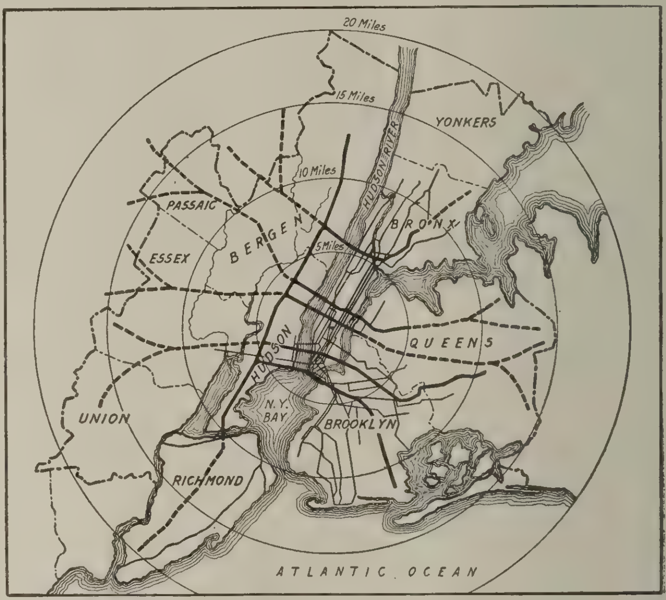


Fig. 3—Map Showing the East and West Lines of the Metropolitan Transit Plan

We know that the old law thought to be fundamental during the period of development of electric traction, that the riding per annum per capita of population increased as the square of the population, cannot be applied to an increase from one million to five millions, for instance. In dealing with this matter quantitatively, we must, therefore, be on our guard.

Sub-centers like the retail district of Brooklyn and Newark, will grow in importance and a reaction must set in against such continued increased concentrations. Such a sub-center development will mean more local traffic of a type quite different from that carried by our long rapid transit lines.

Comparative Cost and Passenger Capacities of Different Types of Transportation

The most expensive type of transportation used by urban and suburban travelers in the New York Metropolitan district is the steam railway penetrating to the heart of Manhattan and using a large terminal station. Fortunately for the later solution of the problem the volume of this travel is relatively small compared to the rapid transit and surface lines.

It is a fact, however, which is not generally realized that as a city grows not only does its own local and suburban traffic into these great "steam" railway terminals increase but the long distance travelers grow in number also at an equal or even greater rate. With limited track capacity for carrying these two classes of traffic both cannot increase indefinitely. One or the other must ultimately give way. From this type of transportation we cannot hope for present relief and, on the contrary, part of their load may soon have to be taken over by city rapid transit lines.

A little consideration will show that subways cost per mile of single track thirty-five times as much as a bus line and can only haul seven times as many passengers per hour. This would seem a strong argument for busses. To try to haul a full subway load, however, on a bus system requires seven lines of busses in each direction or a street as wide as Fifth avenue at 42nd street. The cost of widening such a street would be fabulous and far more than the subway. This simply illustrates by a comparison of extremes that each type of transit has a peculiar field of its own and if we attempt to handle bus travel on a subway we will be just as wrong as to attempt to carry subway long haul crowds on busses.

Growth of Different Types of Transportation in Greater New York

During the last ten years the miles of single track has doubled on the rapid transit system of Greater New York. The surface lines have increased their trackage only five per cent. This is explained by the great rapid transit program which has been put through in this time. As a result the rapid transit lines have taken practically all the passenger increase during this period and hence has produced an unusual division of travel as between different types of equipment.

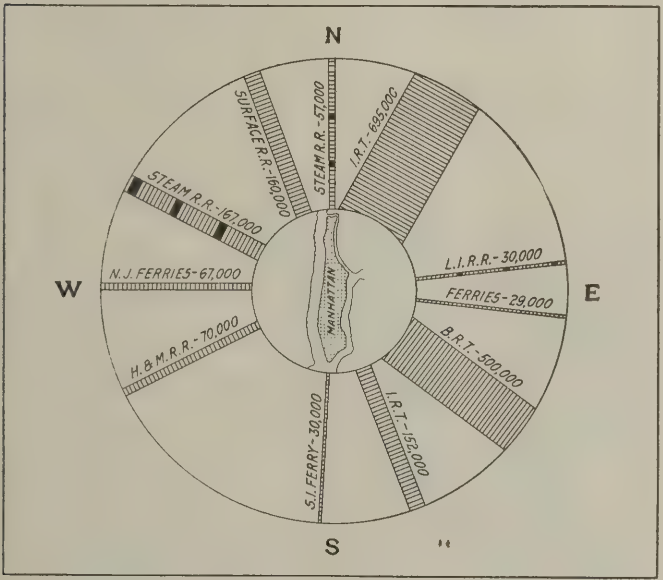


Fig. 4—Chart Showing Total Daily One-Way Traffic to Manhattan

The fact is that taking the whole district into consideration the best service to the public can be obtained by a unified co-ordinated system in which each type of transportation will function to the best advantage and as part of a well balanced whole.

This is a pretty big order but as compared to the process of disintegration and dismemberment which is now taking place it is plainly the right direction in which to work.

The nearer we can approach to a single system distributing its load among its constitutent parts in the most effective way for both service and economy the nearer we will attain to 100 per cent economy and 100 per cent service.

More subways are of course inevitable but let us build them as long haul trunks and feed them with surface lines and busses. Thirty-five per cent of the passengers in the Metropolitan District use surface electric cars today because they are the most convenient. A study of the needs of the Metropolitan District as a whole suggests a necessity for a combined system cheap enough in its outlying sections to permit of wide distribution of travel. If the engineers can put out such a plan then it will be up to the lawyers, city officials and bankers to solve their part of the Metropolitan transportation problem.

Financial Situation

The tendency of cost of transportation in the Greater New York district is to increase more rapidly than the population. In other words, the cost per capita has an alarming upward tendency. This tendency is of course inevitable when we go into the period of city development requiring such expensive means of transit as subways. The desirability of canvassing the possibility of utilizing the cheaper forms of surface and bus transit is obvious.

There is a great preponderance of private investment, so called, which is subject for thought. The comparison of smaller cities is also interesting. Detroit with about one million population and nothing but surface cars has a per capita investment of $40. Chicago with an elevated railway rapid transit system and a very extended surface car system shows $80 investment per capita. New York with its subways doubles this latter figure and seems headed higher.

The Political Question

We have analyzed here together the physical, the operating, and the financial features of this subject but I have purposely omitted mentioning the one great stumbling block in the way of a logical sane solution of this Metropolitan problem, the political question.

Right down the center of the Hudson River we have an artificial political Chinese Wall; the boundary between the State of New York and the State of New Jersey.

Almost one hundred years ago an engineer designed a steam boat that could plow right across this Chinese wall on the surface of the Hudson, more recently engineers have built railway tunnels under this wall and river and today engineers stand ready to build bridges over this wall and across the Hudson River.

As an engineer, let me point out to our political friends how this Chinese wall can be finally and forever removed.

Let us add a 49th State to the Union and name it the State of Manhattan. Let it include the New York Metropolitan district as a single sovereign state—let us leave New York City, Jersey City, Newark, each with its own Mayor, its own local government; but let us place matters of common interest to the whole Metropolitan area such as transportation, water, sewerage and port development in the hands of a governmental body representing the people of all Metropolitan New York.

How to Cut Belts Square

By F. L. Rich

Cutting the ends of a belt to put it into service seems such a simple thing that often the belt man does not give it the consideration necessary to insure the best results, and much of the difficulty with otherwise good belts is due to their not being cut and joined accurately. When a belt runs "wobbly" or races back and forth across the pulleys, it is not giving its best service nor can it have its longest life. Provided that its ends are cut square and it is joined with care, a belt can be made to run as straight as an arrow if the pulleys are true and line up properly.

Don't guess at cutting your belt ends. Use a square—always—and use it with care. If you do not use a square, one or both of the ends will be cut unevenly or irregularly, which prevents smooth running. Even the use of a straight edge does not assure the perfect results obtained by using a square, for the slip of a fraction of an inch will bring the belt ends together at an angle. This results in the belt "shimmying" on the pulleys, which is bad for the belt and impairs its service, for as it moves from side to side, the line of direct pull moves from one side of the belt to the other, imposing shifting and irregular strains, which no belt can stand indefinitely.

There is only one way to assure correct results. That is to use a belt square and to keep it in place until you have cut all the way through the belt. Don't just scratch the surface and then hack through. Cutting to the square assures an even cut all the way through the belt and all the way across. It means that the belt ends can be brought together in a tight, but evenly-running, flush joint. For belts up to 15 or 18 inches wide you can use the ordinary square. Press it firmly against the edge of the belt, and when cutting, hold the knife vertically. Be sure your knife is sharp. Wet the point of your knife occasionally, as the belt is easier to cut when the blade is wet.

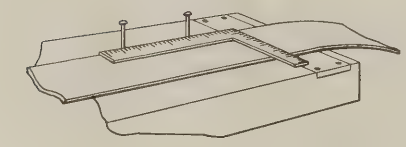


Fig. 1

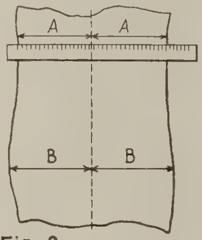


Fig. 2

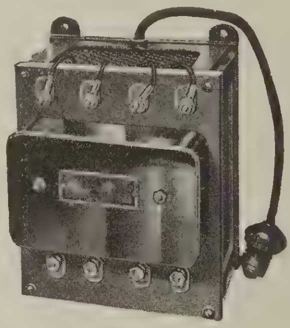
Fig. 1—This Simple Stunt Makes Square Cutting Easy and Positive
Fig. 2—Find the Center By Measuring in From the Edges of the Belt

When a number of belts have to be cut, a good stunt is to drive two nails in a large block of wood, and against these set the edge of the belt and the edge of the square, as shown in Fig. 1. This prevents either the belt or the square slipping. Some men consider it desirable to tack a slip of leather or a piece of old belt on the end of the block to protect the point of the knife as it comes through the belt.

Wide belts are more difficult to square correctly, and the difficulty is often increased by slight variations in width, which throws the square out. To avoid this and assure perfect results, the following method has proved the best. At any point near where you are going to cut the belt, measure across and find the center, as at "A-A," Fig. 2. At any distance back of this, 2 or 3 feet, find the center again, as at "B-B." Between these two center points draw a clean, sharp line. This marks the center axis of the belt.

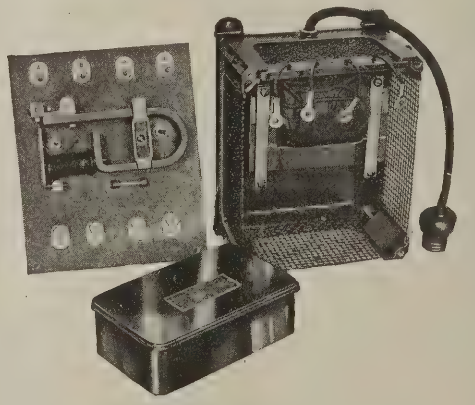
Using the square against the center line, trim off the end of the belt, holding the square firmly in position while you cut all the way through. Two small nails driven in on the center line will keep the square from slipping.

A Rectifier for Battery Charging



Rectifier Assembled for Service

The demand for a means of charging small storage cells from alternating current mains has brought about the development of the mechanical rectifier shown in the illustration. The base contains a small transformer with a set of taps for different voltage batteries. The transformer, which is soaked in a special varnish and baked so as to be practically waterproof, is designed for low iron losses and built of the best silicon transformer sheet steel. The rectifying movement utilizes a patented permanent magnet type of construction with a vibrating armature that connects the battery into the circuit at the proper instant so that a charging current flows into the battery. As only the leakage magnetism of the permanent magnet is utilized, there is no weakening of the magnet after continuous use. The armature is suspended by springs so that there are no pivots or parts to wear out. The contacts are of platinum iridium, and since they operate without sparking, the wear is negligible. In the battery circuit a small fuse is provided for protection. The transformer taps are so arranged that one pair of binding posts can be used for charging either a two or three cell battery, another pair for a four or five cell battery and still another pair for a six or seven cell battery. The resistances of the several circuits are adjusted for ½ ampere current. In case the current is shut off, the rectifier stops, without discharging the battery in the service circuit, and when the power comes on the rectifier automatically starts the charge. This equipment has been placed on the market by the Valley Electric Company, St. Louis, Mo.



Interior of Rectifier

PRACTICAL STUNTS

Locating Short Circuits in Motor Armatures

By W. C. Johnson, Electrician
Norfolk-Southern, Norfolk, Va.

When testing a commutator, before rewinding the armature, it is usually the case that two or more bars will be found short circuited. This can usually be cleared by undercutting the mica, but frequently I have found it necessary to spend a considerable amount of time trying to find the short, and in the operation have filed out a large amount of mica which would be unnecessary if the exact location of the short was known. If a 30-ampere fuse is connected in the place of the test lamp when the test wires are applied to the short circuited bar, an arc will appear at the short, immediately locating the trouble. As these shorts are usually caused by a spot of burnt mica or a copper flake, the arc will appear and burn out before the fuse will blow. Even if the fuse does blow, the cost is small compared to the time lost and the damage done exploring the whole length of the bars.

Fire Extinguishing Bombs

A recent issue of the *National Safety News* presents a unique answer to the question, "What to do with burnt out incandescent lamp bulbs?" It has been discovered that this seemingly useless article can be converted into a convenient inexpensive fire extinguisher in the form of a tetrachloride bomb.

A Tray of Burned Out Electric Globes Converted Into Tetrachloride Bomb Fire Extinguishers

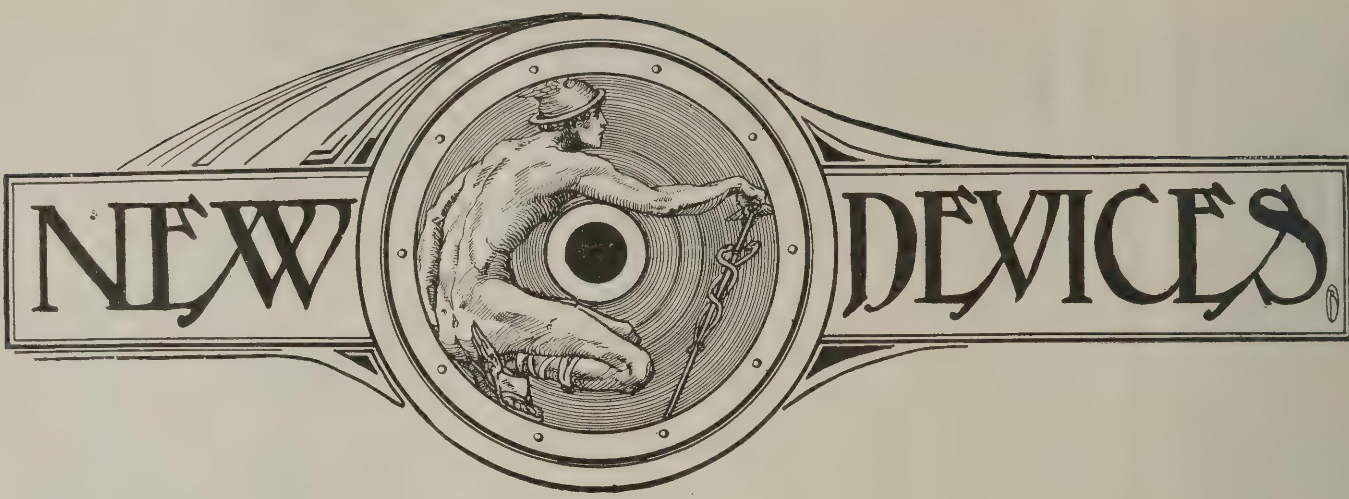
The metallic base is removed from the incandescent lamp, care being taken not to break the glass bulb or destroy the vacuum. The metal is removed not only because it can be used again on other bulbs, but to eliminate the danger of a short circuit which might do more damage than the fire which the bomb puts out. The tip of the bulb is submerged in a pail of carbon tetrachloride, and the tip is then broken off beneath the surface of the liquid. The bulb will then quickly fill with the tetrachloride. The small opening at the tip of the globe is sealed with wax and a handy fire extinguisher is the result.

Finding Small Cracks in a Battery Tank

Small leaks sometimes develop in lead storage battery tanks that are very difficult to locate owing to the fact that the leaks close up with a change of temperature in the battery. The leaks usually show up when the electrolyte is at a high temperature and close up again when it has cooled off. In order to find out exactly where such leaks are located and repair them it is necessary to produce practically the same conditions in the tank as existed when the leak was first discovered—at least as far as the temperature is concerned. These conditions can be duplicated by filling the tank with water at practically boiling temperature. After the water has cooled slightly draw off the water and refill the tank with hot water again. This operation should be repeated several times. The result is that the heat causes the lead to expand. It also warms the compound around the tank and any leak caused by a small flaw or crack in the lead is certain to be found. Cold water is not at all practical for such a test as it chills the sealing compound, usually stopping the leak, which will again open up the next time the battery becomes hot.

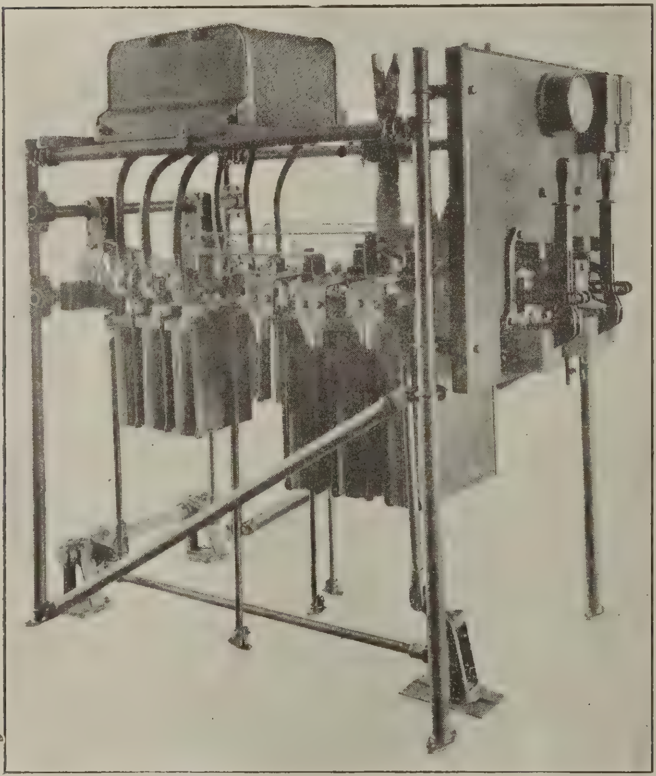
A Home-made Weather Indicator

In addition to the use of burnt out incandescent bulbs for fire extinguishing bombs these bulbs may be used in the following manner to make a simple, yet accurate weather indicator or barometer. File a very small hole in the tip of such a bulb, taking care that the operation is accomplished under water. The water will immediately fill the vacuum of the bulb which is then taken out of the water and suspended by a string with the tip downward. Atmospheric pressure will hold the liquid in the glass except just prior to a storm when a drop of water will form on the tip of the lamp.



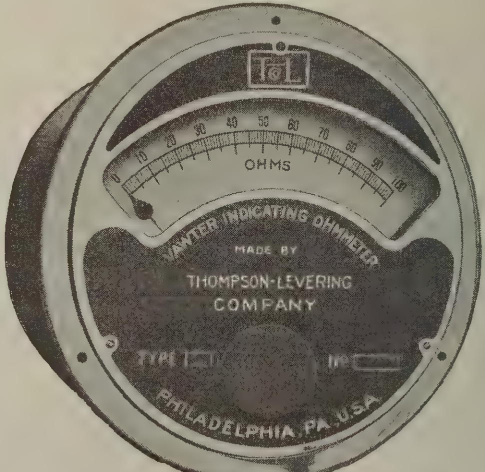
Induction Motor Control Panels

The General Electric Company, Schenectady, N. Y., has completed the standardization of a line of unit switchboard panels for the control of various forms of induction motors. The panels are designed for the control and safeguarding of motors of either the squirrel-cage or wound rotor types.


Three Phase Standard Unit Induction Motor Panel of Heavy Current Capacity for Squirrel Cage Motor

Protection of the motor against incorrect sequence of operation in starting is provided by mechanical and electrical interlocks. Protection against a radical drop in supply voltage is given by an under-voltage device which causes the breaker to open. Unnecessary interruptions of service are avoided by the use of a time-limit trip, but in the event of sustained overload, the breaker in the circuit of the motor opens as determined by the time setting of the relay furnished as a part of the equipment.

The Vawter Indicating Ohmmeter



The Vawter Indicating Ohmmeter

The electrical instrument shown in the illustration is known as the "Vawter Indicating Ohmmeter." It was developed in the laboratories of the Thompson-Levering Company, Philadelphia, Pa., and recently placed on the market by that company because of the demand for a direct-reading electrical instrument for measuring resistances. The resistance to be measured is connected to the line posts and the position of the index on the scale gives the resistance directly. There are no calculations to be made and no dials to adjust. All readings are accurate within one per cent for the standard type, and to within one-tenth of one per cent on a special type that can be furnished when such accuracy is required. The theory of the instrument makes its readings independent of variations, both of voltage of cells and strength of the permanent magnet used. Although this instrument is made for all purposes, the most generally used type is that in which the current supply is obtained from a small flashlight battery contained in the instrument housing.

By simply setting a switch marked "MULT" the scale of the instrument is changed at will to indicate 0.1 for 10 times its calibrated values. It being independent of voltage and magnetic variations, no magnetic shunt is required in its operation nor is any calibration required before making readings. The index stands normally, when not in operation, at any point of the scale, as it is magnetically controlled.

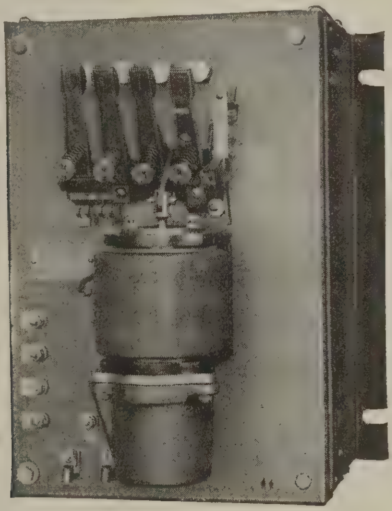
Two equal opposing electromagnetic torques act upon the moving-coil system when indicating a certain resistance and the magnetic flux distribution is such that, on moving the system away from this position, the torque tending to return the system increases while the torque tending to carry the system away diminishes. The difference of these torques constitutes the restoring electro-magnetic torque and produces a state of stable equilibrium.

It is claimed that this magnetic control provides a practical system free from variations in pressure of the operating voltage, within the range, and that it gives two distinct advantages over the indicating spring-controlled ammeters and voltmeters in that its indications are free from variation in the torsion of the control springs and free from the deterioration of the strength of the permanent magnet used.

New Automatic Motor Starter of Time Limit Type

The Cutler-Hammer Mfg. Co. of Milwaukee, Wis., has redesigned its bulletin 6105 time limit automatic starter to include more larger and smaller sizes than formerly. The air dash pot has been replaced by an oil dash pot, with the former optional on the new equipment. The solenoid, plunger and rocker arm have been retained.

The new starter is made in capacities from ½ to 10 hp. at 115 volts, and up to 25 hp. at 230 and 500 volts. The 500 volt sizes are more compact than formerly. The oil dash pot is completely covered so as to be splash proof, and is adjustable for time by an external screw. When the latter is once set, the starter will always cut out the resistor in the same length of time. A non-freezing dash pot oil is used, so temperature conditions will not affect the length of time for starting. The fingers on the rocker arm are of standard C-H drum construction and, like the contact buttons, are renewable. The starter can be controlled from any remote point by a single pole knife, snap switch, pressure or vacuum regulator, float switch, or by three-wire push button control. Low voltage release is inherent with two-wire control and low voltage protection with three-wire.



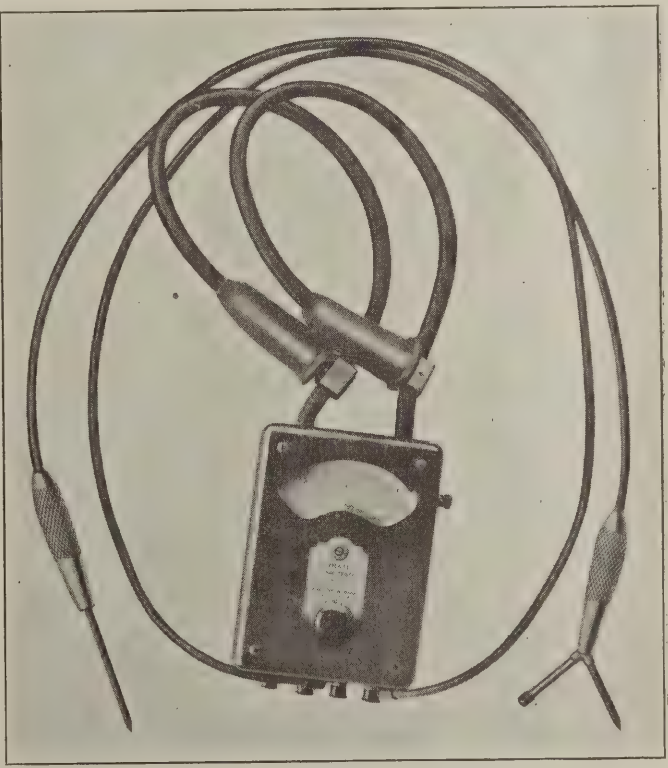
The Accelerating Fingers on This Motor Starter Close One by One As the Solenoid Armature Moves Upward

The starter is mounted on a slate panel carried on a pressed steel wall frame, with the starting resistance self-contained. A starter of this type (time limit acceleration) is particularly adapted for starting direct current motors carrying loads which are liable to vary between wide limits and where remote control is desired, such as with pumps, compressors, and in similar service.

An Instrument for Locating Trouble

The electrical instrument and equipment shown in the illustration has been placed on the market by the Service Station Supply Company, Detroit, Mich., under the name "Hyrate Electro Trouble Detector." This instrument is designed especially for locating trouble in electrical equipment. Among some of its uses may be mentioned the testing of generators to learn if they are generating properly and to locate the cause of failure; the testing of motors and locating trouble when they fail to operate; the testing of switches, cut-outs and wiring for defects or grounds; and for the testing of storage batteries to determine if they are charged and in good condition.

This instrument is a combined volt-ammeter and can be converted from one to the other by turning a small switch provided for the purpose. There are five scales in all with ranges as follows: voltage reading 0 to 0.3, 0 to 3 and 0 to 30; current reading from 0 to 30 and 0 to 300. There are no external shunts or complicated connections to be made. Two prods, one provided with a cadnium electrode, and the necessary leads are furnished. There are also two heavy cables with universal clips attached, for testing circuits. Although this instrument and equipment has been designed primarily for automobile service, it can be readily applied to railroad electrical equipment.



The Instrument With Clips and Testing Prods

General News Section

The Black & Decker Manufacturing Company, Townsend Heights, Md., has recently increased its capitalization by $2,000,000. Of this amount $368,500 was subscribed by the employees. Since closing the books on the above issue so many more requests for subscriptions have been received that the company has decided to open up immediately another block of $150,000 for the benefit of the employees of the organization.

The Falls Rivet Company, Kent, Ohio, has just purchased from the Ohio Wire Goods Manufacturing Company at Akron, Ohio, all the machinery, patents and patterns relating to the manufacture of cotter pins and flat spring keys. The machinery has been moved from Akron to Kent and is now in operation. **Lawrence Kneifel** and other employees of the organization at Akron who were connected with the cotter pin manufacture will become associated with the Falls Rivet Company.

The Federal Power Commission received application covering a projected development of 7,726,651 water horsepower up to and including the week ending November 20. This is very much in excess of the estimate made during the discussion of the water power bill in Congress. The most optimistic estimate made at that time was that applications would be filed during the first year covering about 2,000,000 hp. The applications covering projects on navigable streams involved 4,790,350 hp., while those on public land and reservations involved 2,936,301 hp. The projects which require property valuation involved 738,200 hp.

A Fire in the Glasborough Sub-station on the third-rail electric line on the Atlantic City division of the Pennsylvania Railroad held up traffic for two hours on November 14. Escaping air from an air compressor fanned the fire to an intense heat and made the efforts of the firemen almost futile until the air supply was exhausted. Fire Chief, A. G. Stewart, Jr., attacked the blaze with streams of water after the precaution of shutting off the high voltage current had been taken. The damage to the building is estimated to be about $2,000 while the damage to the machinery was considerably greater.

The New York State Public Service Commission, Second District, has consolidated its divisions covering steam and electric railroads into the Division of Railroads, with Charles R. Vanneman, chief of the Division of Steam Railroads, as chief of the Consolidated division, and Ray G. Winans, assistant inspector, as chief inspector of electric railroads. Charles R. Barnes, chief of the Division of Electric Railroads, resigned recently to become the head of the commission operating the street car lines in Rochester. Mr. Winans was assistant to Mr. Barnes. Mr. Vanneman has been with the commission since March 3, 1910, when he was appointed as inspector of the Division of Transportation. In 1914 he was promoted to be chief of the Division of Steam Railroads. He has supervision over grade crossing work.

The Cutler-Hammer Manufacturing Company, Milwaukee and New York, has recently acquired the property at One Hundred and Thirty-Seventh street and Southern Boulevard, New York, as an additional plant for the manufacture of "Thermoplax" and "Pyroplax" molded insulation. The five-story building on this property has been completely equipped with presses for this work. The New York plant will take care of the company's Eastern business in this line and will relieve the Milwaukee plant. **F. J. Boller,** formerly of the Milwaukee insulation department, is in charge of the new plant.

Twenty-two thousand employees of the **Western Electric Company** are being offered an opportunity to be among the holders of bonds of their corporation. The board of directors has approved an extension of the plan to enable its personnel to purchase Western Electric 5-year 7 per cent. convertible gold bonds. Instead of limiting its investment arrangements to its older employees as has been the custom in the past, the company is encouraging those who have six months' or more continuous service by December 1 to acquire their quota of the securities.

The older employees will also benefit under the new offer. Those who did not subscribe when the bonds were issued originally can apply for their share now. In no case, however, can the total face value of any employee's holdings in the issue exceed $100 for each $300 of his annual rate of pay.

The sale to the employees is on an installment basis, payment being made in a manner similar to that used during the Liberty Loan drives. The subscribers receive interest on the money they pay in and also on the bonds themselves, so that instead of paying the full subscription price of $98.50, the employee's cost is only $89.84 on each $100 bond, or about 8.9 per cent. a year return on the investment. These bonds are now quoted at about 99.

Tenth Anniversary of the Pennsylvania Passenger Station, New York City

Friday, November 26, marked the completion of the first ten years of the Pennsylvania Railroad station in New York City, and the use of the Hudson River tubes. The first train over the Long Island had started out of the terminal and through the East River tube three months before. The through rail connection between New England and the South by way of the Hell Gate Bridge and the New York Connecting Railway, was put in service in April, 1917, and in January, 1918, the freight extension of the New York Connecting Railway to Bay Ridge, Long Island (opposite Greenville, N. J.), was opened to traffic.

The New York improvement of the Pennsylvania System had been authorized by the board of directors in 1902. In the ten years the number of passengers carried to and from the Pennsylvania station has increased over 200 per cent, or from 9,861,427 in 1911 to 30,343,205 in 1919. Pennsylvania Railroad traffic has increased 188.3 per cent and Long Island 214.2 per cent. The Long Island passengers are about two-thirds of the whole.

How the ferry has gone out of business as a passenger carrier is seen in the fact that in 1910, the last year of exclusive ferry service, the Pennsylvania ferries transported 9,372,028 rail passengers, while last year this dropped to 169,772 passengers. The Hell Gate bridge route, with four trains in each direction, carried, in October, 44,561 passengers. This is a development which has been made possible by the use of electric traction.

Australian State to Contract for Electrical Goods

Bids for electrical supplies aggregating $75,000,000 are being invited by the Electricity Commission of the state of Victoria. The equipment will be for the construction of 132,000 volt power station and a 90-mile transmission line. Plans and specifications for the various portions of the project can be obtained from the New York or Chicago offices of the Bureau of Foreign and Domestic Commerce.

Electrification Contemplated in Argentina

The Central North Argentine is having a study made with the view of electrifying its line from Cordoba to Cruz del Eje, a distance of 93 miles, according to reports from the American ambassador at Buenos Aires. The line is said to have a heavy passenger traffic and is favorably situated for recourse to hydro-electric power. The Bureau of Foreign and Domestic Commerce, Washington, D. C., is in possession of the details of the project and will put American concerns interested into connection with the proper officers of the company.

Hoover Heads American Engineering Council

The Federated American Engineering Societies has at last become an independent organization and the work of the Joint Conference Committee of the four founder societies has come to an end. The first meeting of American Engineering Council, its representative group, was held at Washington, in the New Willard Hotel, on November 18, 19 and 20. Herbert Hoover, former food administrator, becomes the active head of the new council, having been unanimously elected president. A total of 21 member societies and nine societies, which have not as yet taken final action, participated in the work.

E. S. Carman, temporary chairman, presided and the real work began with the selection of nominating committees for the executive officers and the members of the executive board. This board consists of 30 members of the American Engineering Council. From the report of the committee it was decided that as there were a number of societies which were expected to join shortly, vacancies should be left on the board in order that these societies might be able to secure proper representation. As a result of this decision four vacancies were left for this purpose, and this, plus the six executive officers who are regular members of the board, left 20 places open out of the full number of 30; they were apportioned by assigning 14 places to the national societies and six to local organizations.

Following the method outlined in the societies' constitution the country was divided into six districts for the locals as follows: District 1, New England and New York; District 2, Michigan, Wisconsin and Minnesota; District 3, Ohio, Indiana and Illinois; District 4, New Jersey, Pennsylvania, Delaware, Maryland, and the District of Columbia; District 5, all the southern states, including Louisiana and Texas, and District 6. all other states west of the Mississippi river. Of the national societies the American Society of Mechanical Engineers received four places; the American Institute of Mining and Metallurgical Engineers, three; American Institute of Electrical Engineers, four; American Institute of Chemical Engineers, one; American Society of Agricultural Engineers, one, and the Society of Industrial Engineers, one.

The executive officers and the members of the executive board, so far as they were elected, are: Herbert Hoover, Palo Alto, Cal., president; Calvert Townley, New York, vice-president; W. E. Rolfe, St. Louis, Mo., vice-president; D. S. Kimball, Ithaca, N. Y., vice-president; J. Parke Channing, New York, vice-president, and L. W. Wallace, Baltimore, Md., treasurer. For the A. S. M. E., L. P. Alford, New York; E. S. Carman, Cleveland, Ohio; A. M. Greene, Jr., Troy, N. Y., and Fred J. Miller, Central Bridge, Pa. For the A. I. E. E., H. W. Buck, New York; William McClellan, Philadelphia, Pa.; C. F. Scott, New Haven, Conn., and L. B. Stillwell, New York. For the A. I. M. E., Edwin Ludlow, New York; A. S. Dwight, New York, and Phillip N. Moore, St. Louis, Mo. For the A. I. C. E., T. E. Howe, Washington, D. C. For Districts 4, 5 and 6, W. W. Varney, Baltimore, Md.; O. H. Koch, Dallas, Texas, and L. B. Smith, Topeka, Kan., respectively.

A. S. C. E. Holds to Engineering Council

As a subsequent move in the stand that the American Society of Civil Engineers has taken in regard to the Federated American Engineering Societies the former has endeavored through a recent resolution to prevent the dissolution of Engineering Council, or at least to prevent it from turning over its activities to the newly organized American Engineering Council. The resolution as passed by the Board of Direction at its meeting of November 9 and made public at the time of the meeting of the federation in Washington, stated that as the American Society of Civil Engineers by a vote of 3,278 to 2,330 had decided not to become a charter member of the federated societies and that as it has been suggested that the work of Engineering Council should be turned over to and be taken up by the said Federated American Engineering Societies: "Be it resolved that the Board of Direction hereby instruct its representatives upon Engineering Council to state to Engineering Council that they cannot participate in any actions transferring its activities to the Federated American Engineering Societies and that the Board instructs its representatives to express to the Council its hope that Engineering Council will for the present carry forward its work."

PERSONALS

J. W. Johnston, chief inspector of car lighting of the Canadian National with headquarters at Toronto, has had his jurisdiction extended to include the Grand Trunk Pacific.

Anatole Gollos, electrical engineer of the Chicago Union Station Company, has been granted leave of absence and has sailed for Europe to look after his interests in connection with his automatic train stop. Mr. Gollos has recently made a radical improvement in his design.

Gordon Fox, formerly connected with the Fort Wayne works of the General Electric Company and later electrical engineer of the Mark plant of the Steel & Tube Company of America, has joined the engineering staff of Freyn, Brassert & Company, consulting engineers of Chicago, in the capacity of electrical engineer. Mr. Fox is chairman of the Chicago Section of the Association of Iron and Steel Electrical Engineers and is a member of the A. I. E. E.

C. M. Harris, manager of the railroad shop section, industrial department, Westinghouse Electric & Manufacturing Company, has been appointed vice-president of the Hagerstown and Frederick Railways Company, which operates interurban railways and central stations in Maryland. Mr. Harris was graduated from Pennsylvania State College in 1901, as an electrical engineer. After filling various positions with the Pennsylvania and the Baltimore & Ohio railroads, he became master mechanic of the Washington Terminal railroad, from which he went with the Westinghouse company to handle the electrical business of railroad shops. Mr. Harris was made manager of the railway shop section last spring.

OBITUARY

J. J. Regan, railway department, General Electric Company, Schenectady, N. Y., died on November 11. Mr. Regan was born in Schenectady in 1876. He received his education at the schools in that city and entered the employ of the General Electric Company at the age of eighteen years. For a number of years he was connected with the railway department of that company, and had a large acquaintance with men identified with railway interests.

George Albert Graber, manager of the Atlanta office for the Kerite Insulated Wire and Cable Company, died suddenly at his home, in Atlanta, Georgia, on Sunday, November 28th, 1920. Mr. Graber was born in Stratford, Ontario, on May 10, 1871. He was educated in the schools of that city; graduated from the Collegiate Institute and entered the newspaper field at an early age. At the time he came to the United States he was private secretary and assistant to the city editor of the Toronto *Empire* and was given important assignments where expert stenographic ability was required.

Soon after reaching his adopted country, Mr. Graber secured employment with Frazier and Chalmers (now Allis-Chalmers Company) and for fourteen years was office manager and private secretary to W. J. Chalmers.

In 1909 Mr. Graber was made manager of the railroad department of the Duntley Manufacturing Company and was one of the pioneers in the development and promotion of gasoline speeders and section cars for railroad use. He became affiliated with the Kerite company in March, 1911, and this relationship remained continuous until the time of his death.

TRADE PUBLICATIONS

General Electric Company of Schenectady, N. Y., during the last few months have issued a number of interesting bulletins. The first of these bulletins, No. 49,400, describes the scientifically perfected Hewlett Link Insulator for power cable transmission. Another bulletin, No. 41,311, which supersedes bulletin No. 4,859, is devoted to a discussion of the use of synchronous condensers and covers the subjects of power-factor control through synchronous condensers, and power-factor correction. A third bulletin, No. 48,715, deals entirely with the subject of insulating fabrics put on the market by the General Electric Company. A fourth pamphlet, bulletin No. 48,704-A, is devoted exclusively to a description of the G-E Insulating Compound.

Machine Tool Control—C-H Controllers is the title of a new 48-page, 8½ x 11, book, known as Publication 845, and published by The Cutler-Hammer Mfg. Co., of Milwaukee and New York. The preface states that the recent changes in manufacturing conditions make it essential to provide better equipment than formerly, easier means of operating, and more accurate and convenient control. The first half of the book is devoted to machine tools of all kinds—lathes, drills, boring machines, planers, milling machines, punch presses, etc., with suggestions for the selection of motor and control apparatus for the different machines. The second half of the book takes up controllers more specifically, both manual and automatic, with illustrations, descriptions, and horsepower ratings.

The Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., has recently distributed four bulletins. Two of these are devoted to the subject of electric traction, one of the pamphlets being entitled "The Regulation and Inductive Effects in Single-Phase Railway Circuits," while the other is devoted to the illustration and description of "Automatic Railway Sub-station." "The Electric Railway and Freight Transportation" is the title of the third of these bulletins which contains many photographs showing the various points throughout the country where freight is being handled by interurban trolley service as well as presenting in more or less detail the facts of the individual cases. The fourth bulletin is on the subject of "Electric Arc Welding" and contains many photographs showing the application of this art in the railroad industry. The latter half of this pamphlet is devoted to the nomenclature of welded joints in which the various types of joints are clearly shown together with the symbols indicating the particular type of joints used. The Westinghouse equipment for electric arc welding is illustrated and described in detail, diagrams and curves being given to bring out the essential facts.

AL Railway Engng.

Railway Electrical Engineer

VOLUME 11 DECEMBER, 1920 NUMBER 12

Published Monthly by Simmons-Boardman Publishing Co., Woolworth Building, New York, N. Y. Subscription price, United States, Canada and Mexico, $3.00 a year; foreign countries, $5.00 a year. Single copies, 35 cents. Entered as second-class matter, January 4, 1916, at the post office at New York, N. Y., under the Act of March 3, 1879.

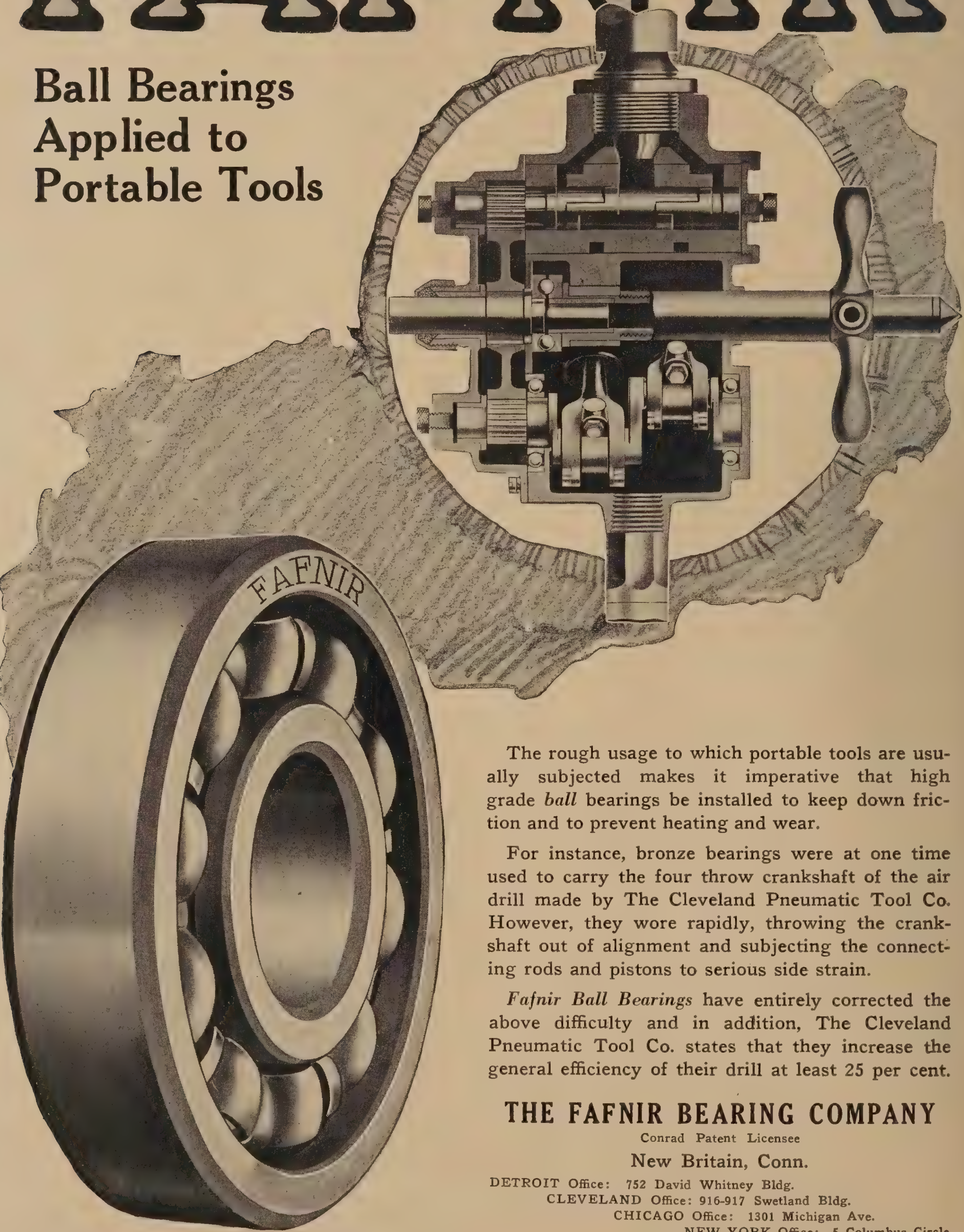
20 1

CHICAGO AND NORTHWESTERN TERMINAL

OKONITE Wires and Cables used exclusively throughout this Terminal, and Standard for Railway Signals.

FAFNIR

Ball Bearings
Applied to
Portable Tools

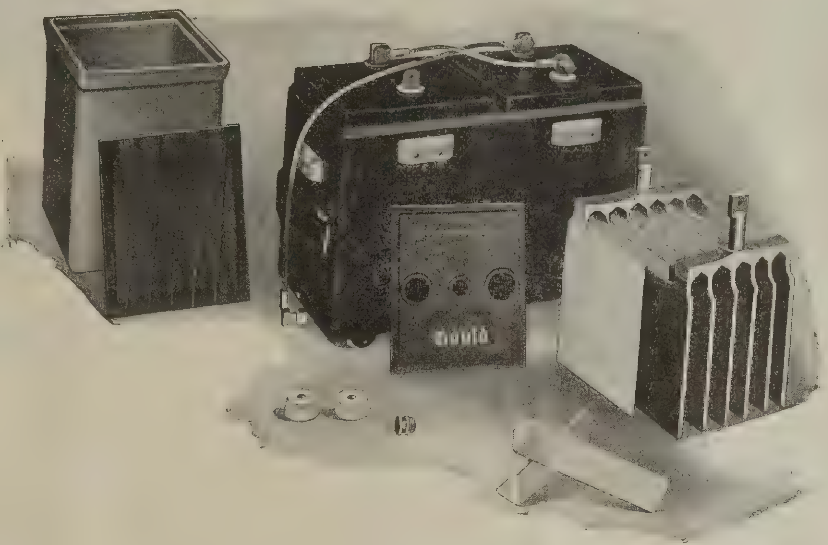


The rough usage to which portable tools are usually subjected makes it imperative that high grade *ball* bearings be installed to keep down friction and to prevent heating and wear.

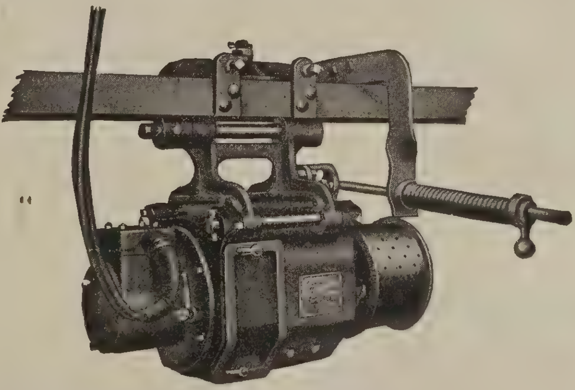
For instance, bronze bearings were at one time used to carry the four throw crankshaft of the air drill made by The Cleveland Pneumatic Tool Co. However, they wore rapidly, throwing the crankshaft out of alignment and subjecting the connecting rods and pistons to serious side strain.

Fafnir Ball Bearings have entirely corrected the above difficulty and in addition, The Cleveland Pneumatic Tool Co. states that they increase the general efficiency of their drill at least 25 per cent.

THE FAFNIR BEARING COMPANY
Conrad Patent Licensee
New Britain, Conn.
DETROIT Office: 752 David Whitney Bldg.
CLEVELAND Office: 916-917 Swetland Bldg.
CHICAGO Office: 1301 Michigan Ave.
NEW YORK Office: 5 Columbus Circle



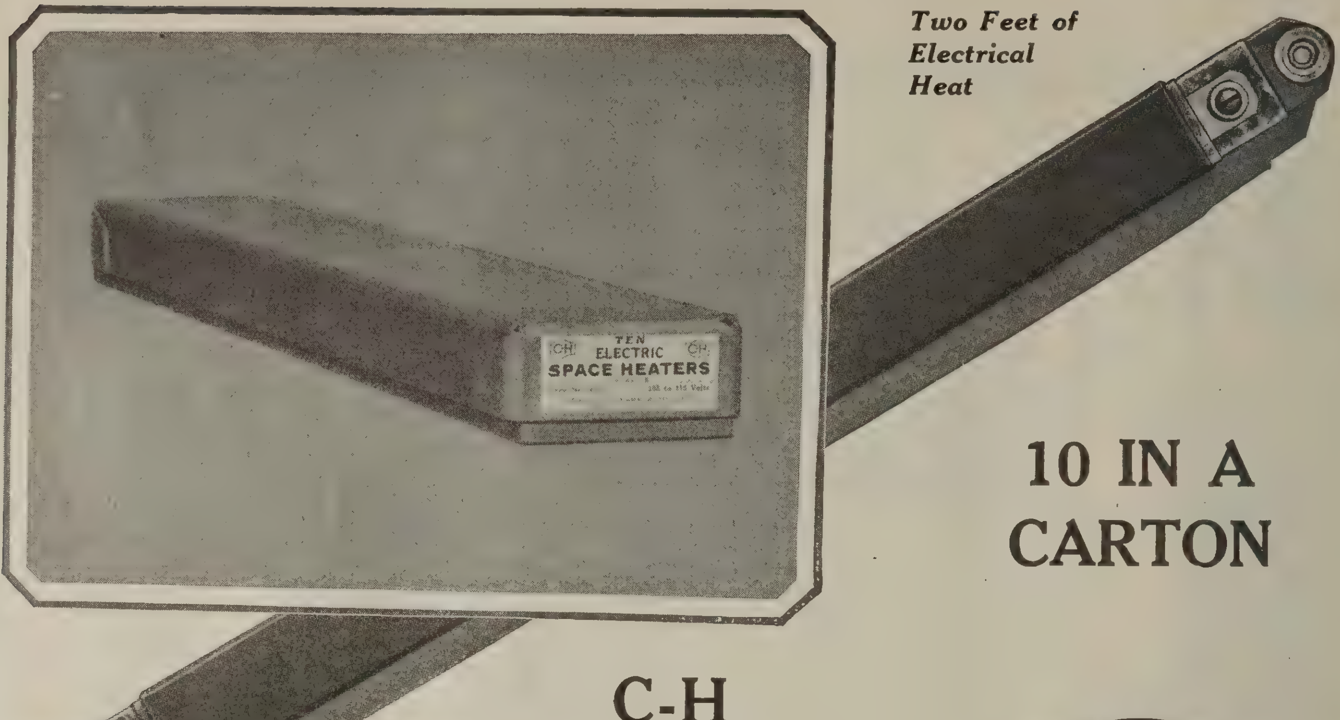
GOULD "SIMPLEX" SYSTEM



STANDARD TRUCK GENERATOR BODY MOUNTED

GOULD COUPLER CO.
GOULD STORAGE BATTERY CO.

New York Chicago San Francisco
Works: Depew, N. Y.



Two Feet of Electrical Heat

10 IN A CARTON

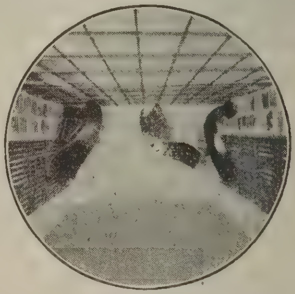
C-H Electric Space Heaters

These two foot heaters are only 3/16-inch thick and provide the most flexible method of heating crane cabs, sprinkler systems riser and valve houses, watchman houses, exposed rooms, sub-stations, and are used for drying out armatures, in sump pits, airplane hangars, scale rooms, negative drying cabinets, japanning and other low temperature ovens, for porcelain baking, and in a thousand and one other ways.

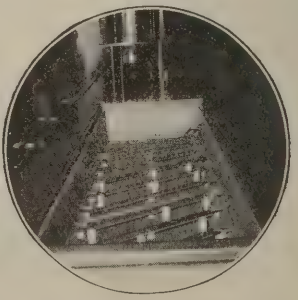
Because of the widespread use during the past four years, these heaters are now carried by the electrical supply houses from whom you can obtain them. The standardized construction and large production are the reasons for the low price of $3.00.

When ordering specify voltage of the light or power circuit on which they are to be installed.

In the limited space available in crane cabs the flat C-H Heater is particularly suited. Can also be put under perforated plate on which operator stands.



The installation in ovens can be well done by connecting Space Heaters by means of bus bars.



The copper water bath is not needed in cafeteria serving counters if Space Heaters are arranged as shown.

Send for This Book

Sold by Electrical Supply Houses

Made by

THE CUTLER-HAMMER MFG. CO.
Industrial Heating Department
Works: Milwaukee and New York

District Offices: New York: 50 Church St. Chicago: 323 No. Michigan Ave. Boston: 77 Franklin St. Pittsburgh: Farmers' Bank Bldg. Philadelphia: Commonwealth Bldg. Cleveland: Guardian Bldg. Cincinnati: Gwynne Bldg. Detroit: Kresge Bldg. **Sellings Agents:** H. B. Squires Co., San Francisco: 583 Howard St., Los Angeles: 308 S. 3rd St., Seattle: 552 First Ave., So. General Machinery Co., Birmingham: Brown-Marx Bldg.

Railway Electrical Engineer

Published on the Second Thursday of every month by the
SIMMONS-BOARDMAN PUBLISHING COMPANY
Woolworth Bldg., New York.

Chicago: Transportation Bldg. Cleveland: 341 The Arcade
Washington: Home Life Bldg. Cincinnati: First National Bank Bldg.
London, England: 34 Victoria Street, Westminster, S. W., 1.
Cable address: Urasigmec, London.

Edward A. Simmons, President.
Lucius B. Sherman, Vice-Pres. Samuel O. Dunn, Vice-Pres.
Henry Lee, Vice-Pres. and Treas. Cecil R. Mills, Vice-Pres.
Roy V. Wright, Secretary.

Alfred G. Oehler, Editor.
Chas. J. Corse, Managing Editor. B. W. Meisel, Associate Editor.

Subscription, including postage: United States, Canada and Mexico, $3.00 a year; Foreign Countries, $5,00 a year; single copy, 35 cents. Foreign subscriptions may be paid through our London office (34 Victoria Street, S. W., 1), in £—s—d.

Entered as second class matter, January 4, 1916, at the post office at New York, New York, under the act of March 3, 1879.

WE GUARANTEE, that of this issue 2,900 copies were printed; that of these 2,900 copies, 2,422 were mailed to regular paid subscribers, 70 were mailed to advertisers, 22 were mailed to employees and correspondents, and 386 were provided for new subscriptions, samples, copies lost in the mail and office use; that the total copies printed this year to date were 36,425, an average of 3,035 copies a month.

THE RAILWAY ELECTRICAL ENGINEER is a member of the Associated Business Papers (A. B. P.) and of the Audit Bureau of Circulation (A. B. C.).

Volume 11 December, 1920 Number 12

Table of Contents

Editorials:

How to Keep High Wages 435
A Difficult Period 435
Electrical Progress Of The Year 435
Roundhouse Lighting 436
The January Number 436
New Books 436
Electrical Equipment at New Engine Terminal 437
Advantages of Steam and Electric Locomotives 439
A Study of the Electric Arc Welding of Steel 441
New Enclosed Cab Switch 446
Controllers for Alternating Current Motors 447
Lighting for Locomotive Terminals 456
Basis for Comparing Locomotive Maintenance Costs 457
Principles of Car Lighting by Electricity 459
The Future Transportation of Greater New York 465
How to Cut Belts Square 470
A Rectifier for Battery Charging 470

Practical Stunts:

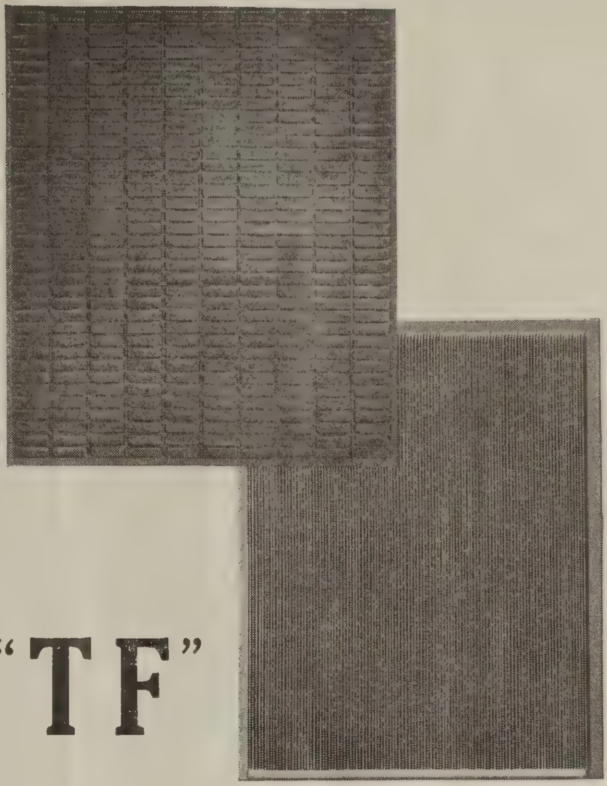
Locating Short Circuits in Motor Armatures 471
Fire Extinguishing Bombs 471
Finding Small Cracks in a Battery Tank 471
Home Made Weather Indicator 471

New Devices:

Induction Motor Control Panels 472
The Vawter Indicating Ohmmeter 472
New Automatic Motor Starter 473
An Instrument for Locating Trouble 473

General News Section:

General News 474
Personals 476
Trade Publications 476



"TF"

That Stands for Battery Efficiency

Remember, when you are discussing the Willard "T F", that this is the battery needing only *one* cleaning in an operating period of four years—half that of the ordinary Planté battery.

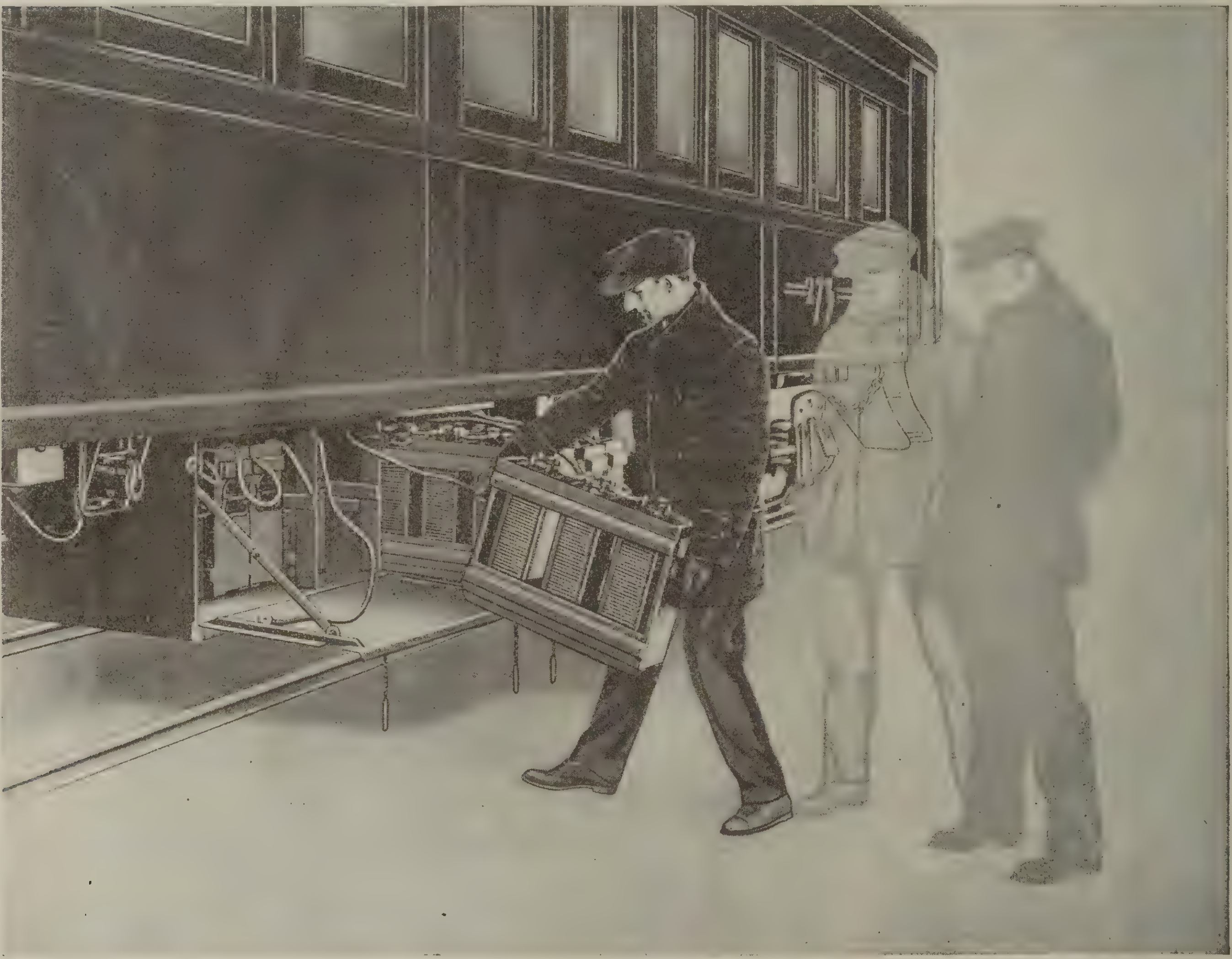
The "T F" uses nearly 1/3 less lead than the Planté battery and is correspondingly lighter. It takes considerably less floor space and sells at a lower price than a Planté plate battery of equal capacity.

Willard Storage Battery Company
Cleveland, Ohio

Willard STORAGE BATTERY
CONSERVATION

To save money on the upkeep of train lighting batteries, use EDISON STORAGE BATTERIES. One man can do the work of three, releasing men for other important work. Compact, light weight and dependable, Edison batteries perform faithfully and efficiently. They have become standard on roads giving good service and showing lowest maintenance cost. Made of iron and steel, they last with a minimum of labor effort.

Write for Bulletin 118.



Simplicity, Safety,
Reliability, Rugged.

EDISON STORAG

FACTORY AND MAIN OFFIC

DISTRI

NEW YORK BOSTON CHICAGO DETROIT CLEVELAND
SEATTLE SAN FRANCISCO LOS ANGELES DENVER

Dependable railroad signaling assured with the use of Edison Storage Batteries. Economy and ease of maintenance, combined with durability and a long life. Used on prominent roads throughout the country, Edison batteries are a standard feature of safety. They give efficient service at a minimum of maintenance cost. They stand up. The secret of their strength and permanence is due to their different construction—iron and steel with an alkaline (non-acid) solution. Its built to last and to serve.

Send for Bulletin 104

BATTERY COMPANY

T ORANGE, NEW JERSEY

TORS AT

KANSAS CITY	NEW ORLEANS	ATLANTA	WASHINGTON
PITTSBURGH	PHILADELPHIA	BUFFALO	NEW HAVEN

Strength, Power,
Economy, Permanence

A Man Has Made a Better Light—

Four-in-one semi-indirect lighting units are especially adapted for the illumination of stores, office buildings, school rooms, assembly halls, and many other places. Four-in-ones furnish a softly diffused light from which tiresome glare is noticeably absent. Four-in-one lights are most attractive in appearance and pleasing in effect.

The Four-in-One unit illustrated here is only one of many, there being a variety of designs. The beautiful Gothic type can be furnished in several finishes, the standard being Old Ivory and Antique Gold.

We kindly request you to write our "Lighting Division" for more complete information, which will be cheerfully furnished without any obligation on your part.

OKONITE TAPE

The Standard For Rubber Insulating Tape—

This Package Contains
TO MAKE PERFECT JOINTS USE
OKONITE
OKONITE TAPE
INSTRUCTIONS.
A THOROUGHLY WATERPROOF JOINT.
THE APPLICATION OF HEAT PREFERABLE, BUT NOT ABSOLUTELY NECESSARY
One-Half Pound of Tape.

Okonite Tape is a vulcanized rubber compound tape for insulating splices in wires and cables. It is made with the same high-grade rubber compounding ingredients, and care that characterize OKONITE insulation.

As Okonite Tape is unvulcanized, it readily moulds into a homogeneous mass and makes the splice impervious to moisture and the equal electrically and mechanically of the insulated wire itself.

Okonite Tape has no equal and should always be used to obtain perfect splices.

Standard stock package is ½ pound of ¾ inch tape, but any width and any weight roll can be furnished.

Central Electric Company
FOUNDED 1887
OKONITE IT NEVER DISAPPOINTS
The House of Service
DISTRIBUTING GE JOBBER
316-326 South Wells Street
CHICAGO

D&W
REG. U.S. PAT. OFF.

OIL FUSE CUTOUTS

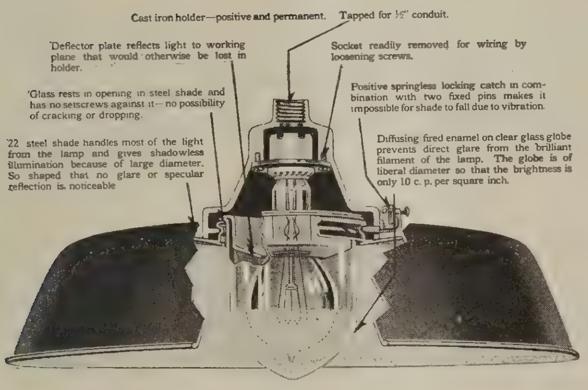
In the "D & W" Cutout, the fusible element is placed under a heavy body of special oil. On the blowing of the fuse the terminals are so arranged that they are forcibly thrown apart and the oil is interposed between them, effectually preventing the formation of an arc. Exhaustive tests have been made under normal and abnormal conditions and its operation has been so perfect as to prove beyond question its value as a protective device.

Furthermore, the universal satisfaction given by the large number of these cutouts during their four years in commercial operation bears indisputable evidence of their worth.

Write for Catalogue No. 2

THE MAXOLITE DIFFUSER

"A Remarkable Development For Industrial Lighting"


Cast iron holder—positive and permanent.
Tapped for ½" conduit.
Deflector plate reflects light to working plane that would otherwise be lost in holder.
Socket readily removed for wiring by loosening screws.
Glass rests in opening in steel shade and has no setscrews against it—no possibility of cracking or dropping.
Positive springless locking catch in combination with two fixed pins makes it impossible for shade to fall due to vibration.
22 steel shade handles most of the light from the lamp and gives shadowless illumination because of large diameter. So shaped that no glare or specular reflection is noticeable
Diffusing fired enamel on clear glass globe prevents direct glare from the brilliant filament of the lamp. The globe is of liberal diameter so that the brightness is only 10 c. p. per square inch.

The Maxolite Diffuser has been designed as a result of demand for an industrial fixture which will have high efficiency and uniform light distribution combined with an intrinsic brilliancy so low that it will not unpleasantly affect the eye.

The unit is made particularly for use with a 200-Watt Mazda C lamp, as this type of fixture, properly spaced so as to eliminate shadows and give uniformity, requires a 200-Watt lamp to provide the desired amount of light.

The Maxolite Diffuser is especially recommended in Machine Shops, Textile Mills, Woodworking Plants, and all other places where close work is done. Where some of these units have already been installed a most pleasing appearance of the room has been effected, resulting in greater production and lowering of spoilage.

The Maxolite Diffuser is the Best—

Send in your order today and convince yourself. Write our "Lighting Division" for Maxolite bulletin No. 75.

Central Electric Company
FOUNDED 1887
The House of Service
OKONITE IT NEVER DISAPPOINTS
DISTRIBUTING GE JOBBER
316-326 South Wells Street
CHICAGO

BUS

Large

WHEN it was necessary four years ago to go into the open markets and purchase materials at unheard-of prices—when the War Department required the entire output of enormous factories, it was common knowledge that quality was more important than price.

Despite the opportunities for purchase in the established markets, **business, large and small** will find it equally as convenient and vastly more economical to purchase from the War Department.

The quality that then satisfied the best engineering and production brains in the country predominates in the sale of electrical equipment now offered to the business men of the country on a Fixed Price basis.

Other firms have found through careful inspection and investigation that every item offered has satisfied their high and long established standards of quality.

It is obvious that no manufacturers can be too big—his standards of quality too high nor can any manufacturer, regardless of his size afford to ignore the extraordinary sale.

SURPLUS PROPERTY BRANCH
WAR DEPARTMENT
OFFICE OF THE QUARTERMASTER GENERAL
MUNITIONS BUILDING WASHINGTON, D. C.

DISCOUNTS

Sales amounting to $100,000 to $250,000—10%

Sales amounting to 250,001 to 350,000—15%

Sales amounting to 350,001 to 450,000 20%

Sales on entire remaining balance in one sale—25%

Sales on entire quantity of Linemen's tool belts and wooden barrow reels—10%

REPEATING COILS

Quantity 4. Type, repeating W.E. 27-F. Fixed Price $3.50 each. Located at Philadelphia, Pa. Order through New York City.

S.P.D. No. 3006.

RETARDING COILS

Quantity 4. Type, retarding, W.E. 57-A. Fixed Price $8.00 each. Located at Philadelphia, Pa. Order through New York City.

S.P.D. No. 3007.

KNOBS, PORCELAIN

Quantity 500. Type, split 2 line. Fixed Price .048 each. Located at Philadelphia, Pa. Order through New York City.

S.P.D. No. 1255.

In ordering, address the Depot Quartermaster at the addresses given below and mention M. E. M. List No. 12, giving the S. P. D. number of the commodity desired.

Boston, Mass.
Army Supply Base.

New York, N. Y.
461 Eighth Avenue.

San Antonio, Texas.

NESS
nd Small

SUPPORTERS

Quantity 950. Type, messenger clamp. Fixed Price .12 each. Located at Ft. Wood, New York Harbor. Order through New York City.
S.P.D. No. 1206.

BRIDGES

Quantity 13. Type, Wheatstone W.E. No. 1407. Fixed Price $80.00 each. Located at Chicago, Ill. Order through Chicago, Ill.
S.P.D. No. 3069.

LINEMAN'S TOOL BELTS

Quantity 2,144. Type, W. rings and safety straps. Mfd. by Mathias Klein & Company, Chicago, Ill. Fixed Price $5.60 each. Located at Philadelphia, Pa. Order through New York City.
S.P.D. No. 3465.

LINEMAN'S TOOL BELTS

Quantity 400. Type, W. rings and safety straps. S.C.G.S.D. Mfr. Buckman Mfg. Co., New York City. Fixed Price $5.60 each. Located at Ft. Wood, New York Harbor. Order through New York City.
S.P.D. No. 1010.

REELS

Quantity, 2,000. Type, wood, reinforced and braced with metal braces. Fixed Price $4.00 each. Located at Philadlephia, Pa. Order through New York City. S.P.D. No. 3504. These reels were manufactured by M. Klein & Co., Chicago, Ill.

REELS

Quantity 110. Type, wood, Barrow (payout). Fixed Price $5.60 each. Located at Ft. Sam Houston, Texas. Order through San Antonio, Texas.
S.P.D. No. 968. These reels were manufactured by M. Klein & Co., Chicago, Ill.

REELS

Quantity 1599. Type, wood, Barrow (payout). Fixed Price $5.60 each. Located at Chicago, Ill. Order through Chicago, Ill.
S.P.D. No. 96. These reels were manufactured by M. Klein & Co., Chicago, Ill.

WIRE

Quantity 541,277 ft. Type No. 14, B & S H D.—tw. pr. Fixed Price per M ft. $13.92. Located at Army Reserve Depot, New Cumberland, Pa. Order through New York City. S.P.D. No. 2229.

WIRE

Quantity 26,060,430 ft. Type O.D. T. P. No. 17 B and copper clad. Fixed Price per mile $54.304. Located at Army Reserve Depot, New Cumberland, Pa. Order through New York City. S.P.D. No. 2230.

WIRE

Quantity 100,000 ft. Type house No. 19 tw. pr. 36 mils. for inside wiring purposes, used principally for telephone work. Rubber covered single braided, olive green with red and green tracers. Fixed Price $9.68 per M. ft. Location Philadelphia, Pa. Order through New York City. S.P.D. No. 13586.

WIRE

Quantity 100,000 ft. Type house, 36 mils. tw. pr. soft copper, each conductor A-26 (new). Insulated with rubber compound and cotton braid. Coils packed in boxes. Fixed Price $9.68 per M. ft. Location Fontana Whse., Ft. Mason, Cal. Order through San Francisco, Cal. S.P.D. No. 13587.

WIRE

Quantity 100,000 ft. Type house, 36 mils. tw. pr. Used for interior house wiring, rubber insulation, cotton covered, slate colored with red dots. Fixed Price $9.68 per M. ft. Location Signal Se., Army Base, Brooklyn, N. Y. Order through New York City. S.P.D. No. 13588.

WIRE

Quantity 30,011 ft. Type outside dist., No. 17. Fixed Price $10.24 per M. ft. Location Camp Franklin, Md. Order through New York City. S.P.D. No. 10150.

WIRE

Quantity 185,920 ft. Type inside, tw. pr., No. 17. Fixed Price $10.24 per M. ft. Location Camp Franklin, Md. Order through New York City. S.P.D. No. 10151.

CABLE

Quantity 1,000,560 ft. Type lead covered telephone, 10 pr. No. 22 ga. Fixed Price $60.32 per M. ft. Location New Cumberland, Pa. Order through New York City. S.P.D. No. 3550.

CABLE

Quantity 47,520 ft. Type lead covered, 10 pr. No. 22 ga. Fixed Price $60.32 per M. ft. Location New Cumberland, Pa. Order through New York City. S.P.D. No. 3550.

CABLE

Quantity 79,200 ft. Type lead covered telephone, 10 pr., No. 22 ga. Fixed Price $60.32 per M. ft. Location New Cumberland, Pa. Order through New York City. S.P.D. No. 3550.

CABLE

Quantity 311,520 ft. Type 15 pr., lead covered No. 22 ga. Fixed Price $73.25 per M. ft. Location New Cumberland, Pa. Order through New York City. S.P.D. No. 3550.

Information on other interesting items may also be had upon inquiry at these addresses.

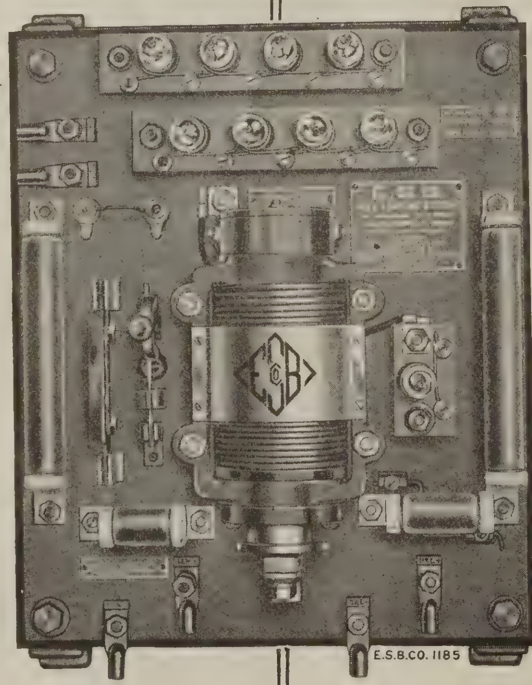
tlanta, Ga.
ransportation Bldg.

Chicago, Ill.
1819 West 39th Street.

San Francisco, Calif.
Fort Mason.

Still Another Reason—The E. S. B. Constant Voltage System Assures Steady Lights

The Constant Voltage Control



Through this exclusive feature of the E. S. B. Constant Voltage Axle Lighting System a constant, "floating" voltage is maintained at the battery terminals, so close to the normal lamp voltage that no lamp regulator is required.

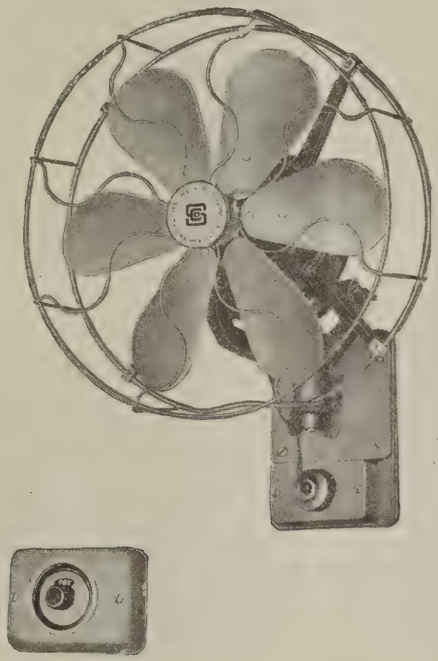
Thus, the variable and uncertain voltage drop of the lamp regulator is eliminated. There are no carbon piles, dash pots, or other movable parts to be jarred by the vibration and jolting of the train. Steady illumination is therefore assured.

The constant Voltage Control also eliminates the necessity for adjustments, which is one of the reasons why the E. S. B. system is so economical to maintain.

Send for Bulletin 154 describing this system and giving records of its actual performance.

THE ELECTRIC STORAGE BATTERY CO.
Oldest and largest manufacturers in the world of storage batteries for every purpose
1888 PHILADELPHIA 1920
Branches in 17 Cities
Special Canadian Representatives: Chas. E. Goad Engineering Co., Ltd.,
Toronto and Montreal.

SAFETY BRACKET FAN



THE SAFETY ELECTRIC BRACKET FAN is designed and built for Railway Car Service.

A Six-Blade Fan operating at lower speed and displacing more air than the four-blade type.

Ball-Bearing Armature with adjustable inner and outer races, eliminating noise of worn bearings, reducing wattage consumption, and requiring less frequent lubrication.

Simplicity in mechanical and electrical construction.

Minimum operating cost.

THE SAFETY CAR HEATING & LIGHTING CO.

NEW YORK CHICAGO ST. LOUIS BOSTON
PHILADELPHIA SAN FRANCISCO MONTREAL

LOW MAINTENANCE

Stone Franklin Lighting operates on the same principle as the stationary power plant generator speed control.

This gives perfect commutation and constant generator efficiency throughout varying train operating conditions.

It gives minimum electrical and mechanical stresses on the armature.

It eliminates delicate electrical regulating apparatus.

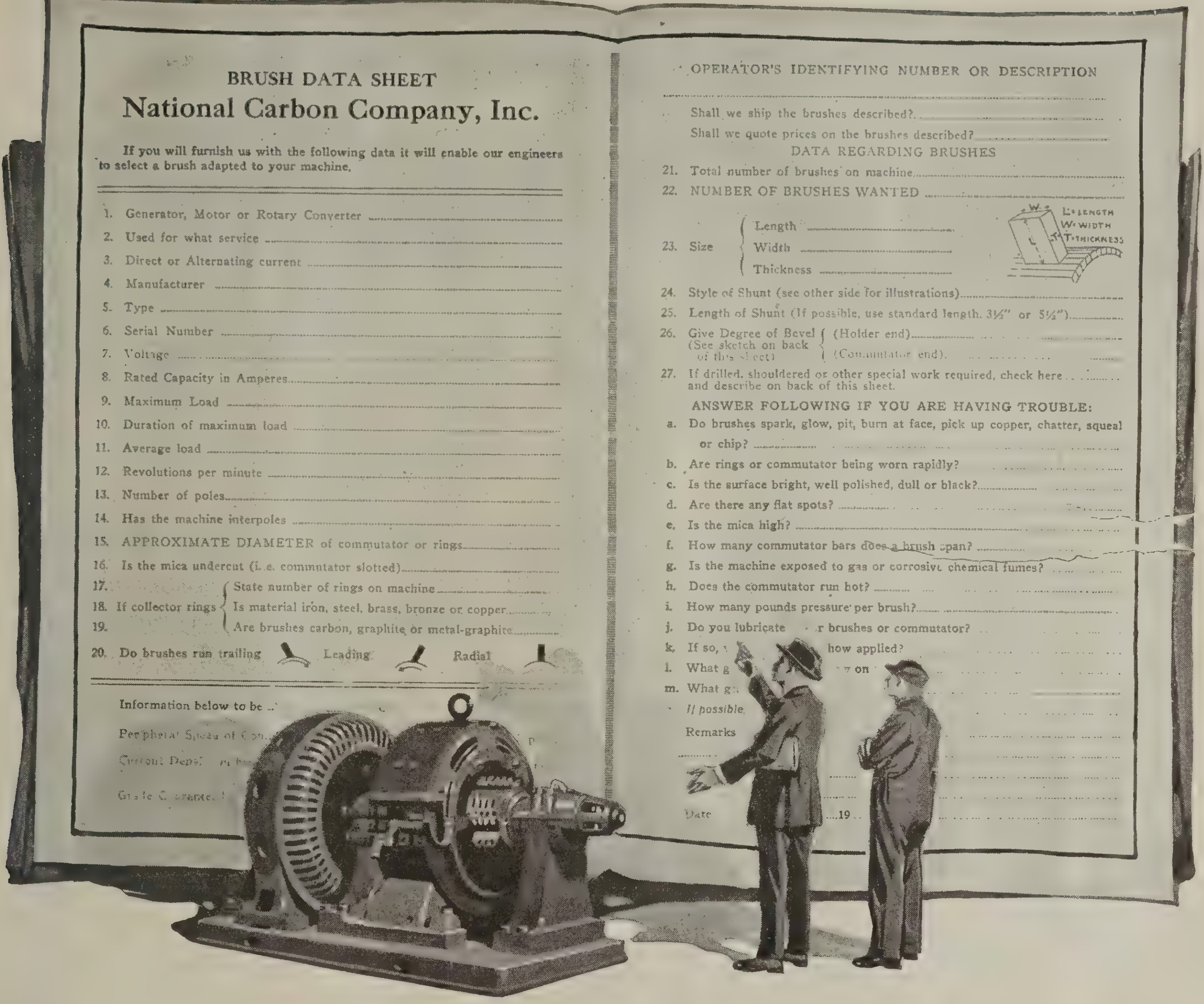
It gives low belt tension and long life.

Each and every one of these advantages are vital factors in reducing the maintenance cost of car lighting equipment.

Stone Franklin Company

18 East 41st Street
New York

Transportation Bldg.
Montreal



BRUSH DATA SHEET

National Carbon Company, Inc.

If you will furnish us with the following data it will enable our engineers to select a brush adapted to your machine.

1. Generator, Motor or Rotary Converter
2. Used for what service
3. Direct or Alternating current
4. Manufacturer
5. Type
6. Serial Number
7. Voltage
8. Rated Capacity in Amperes
9. Maximum Load
10. Duration of maximum load
11. Average load
12. Revolutions per minute
13. Number of poles
14. Has the machine interpoles
15. APPROXIMATE DIAMETER of commutator or rings
16. Is the mica undercut (i. e. commutator slotted)
17. If collector rings — State number of rings on machine
18. If collector rings — Is material iron, steel, brass, bronze or copper
19. If collector rings — Are brushes carbon, graphite or metal-graphite
20. Do brushes run trailing Leading Radial

Information below to be

Peripheral Speed of Com

Current Dens

Grade Co

OPERATOR'S IDENTIFYING NUMBER OR DESCRIPTION

Shall we ship the brushes described?

Shall we quote prices on the brushes described?

DATA REGARDING BRUSHES

21. Total number of brushes on machine
22. NUMBER OF BRUSHES WANTED
23. Size — Length / Width / Thickness
24. Style of Shunt (see other side for illustrations)
25. Length of Shunt (If possible, use standard length. 3½" or 5½")
26. Give Degree of Bevel (See sketch on back of this sheet) — (Holder end) / (Commutator end).
27. If drilled, shouldered or other special work required, check here and describe on back of this sheet.

ANSWER FOLLOWING IF YOU ARE HAVING TROUBLE:

a. Do brushes spark, glow, pit, burn at face, pick up copper, chatter, squeal or chip?
b. Are rings or commutator being worn rapidly?
c. Is the surface bright, well polished, dull or black?
d. Are there any flat spots?
e. Is the mica high?
f. How many commutator bars does a brush span?
g. Is the machine exposed to gas or corrosive chemical fumes?
h. Does the commutator run hot?
i. How many pounds pressure per brush?
j. Do you lubricate r brushes or commutator?
k. If so, how applied?
l. What g on
m. What g

If possible,

Remarks

Date ....19..

Same motor: *different work, different brushes*

BRUSH requirements vary with the application of the motor or generator. What is correct for a motor or generator in one case may be entirely wrong for the same motor or generator in another.

Only careful analysis of the service conditions will assure the best results from each unit. The investigation and analysis of these conditions is the function of Columbia Data Sheet Service.

At your request Columbia Brush Specialists will examine your machines—each machine individually—and ascertain exact conditions of operation.

They pass these facts to our Board of Engineers, which analyzes the facts and specifies correct brushes for each machine. The Columbia Pyramid Brushes recommended are guaranteed to give satisfaction in service.

You are invited to avail yourself of this service. It is at your command whether you have one unit or a thousand.

Columbia Data Sheet Service Solves Your Brush Problems

Write the address below

N C C

NATIONAL CARBON COMPANY

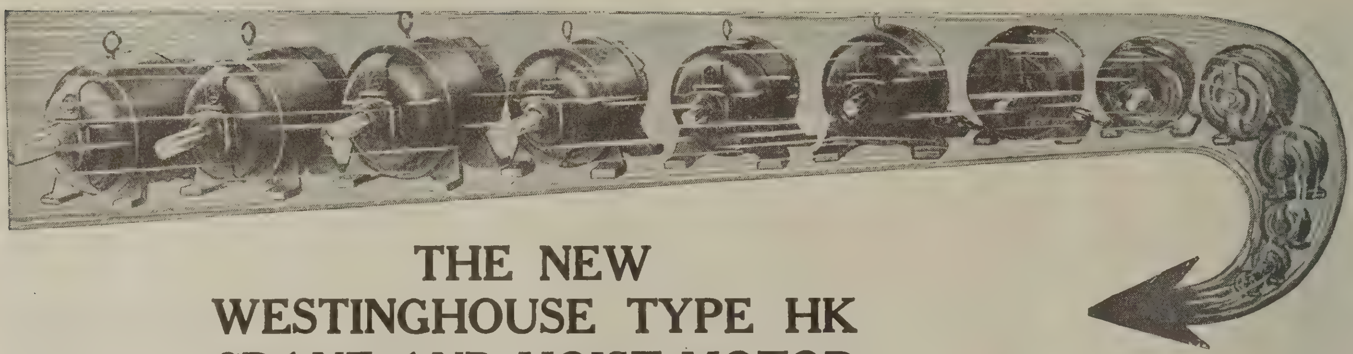
Incorporated

Cleveland, Ohio **San Francisco, Calif.**

Canadian National Carbon Co., Limited, Toronto

41220

A New Line



THE NEW WESTINGHOUSE TYPE HK CRANE AND HOIST MOTOR

was designed especially for severe intermittent, varying speed service where high starting torque is required and where the load consists of a series of starts, stops and reversals.

The chief features of the type "HK" motors are admirable performance, compact construction, light weight and great mechanical strength; the motor frame being made of forged open hearth steel.

W WESTINGHOUSE ELECTRIC

Commutation is beyond criticism; owing to well balanced design and the influence of commutating poles there is practically no sparking under any condition of load or speed within the rated capacity.

Large tapered shafts facilitate the removal of pinion and brake wheel.

The bearings are dust-proof. The bearing surface is very liberal in area and when the motor is operating large oil rings keep them well lubricated.

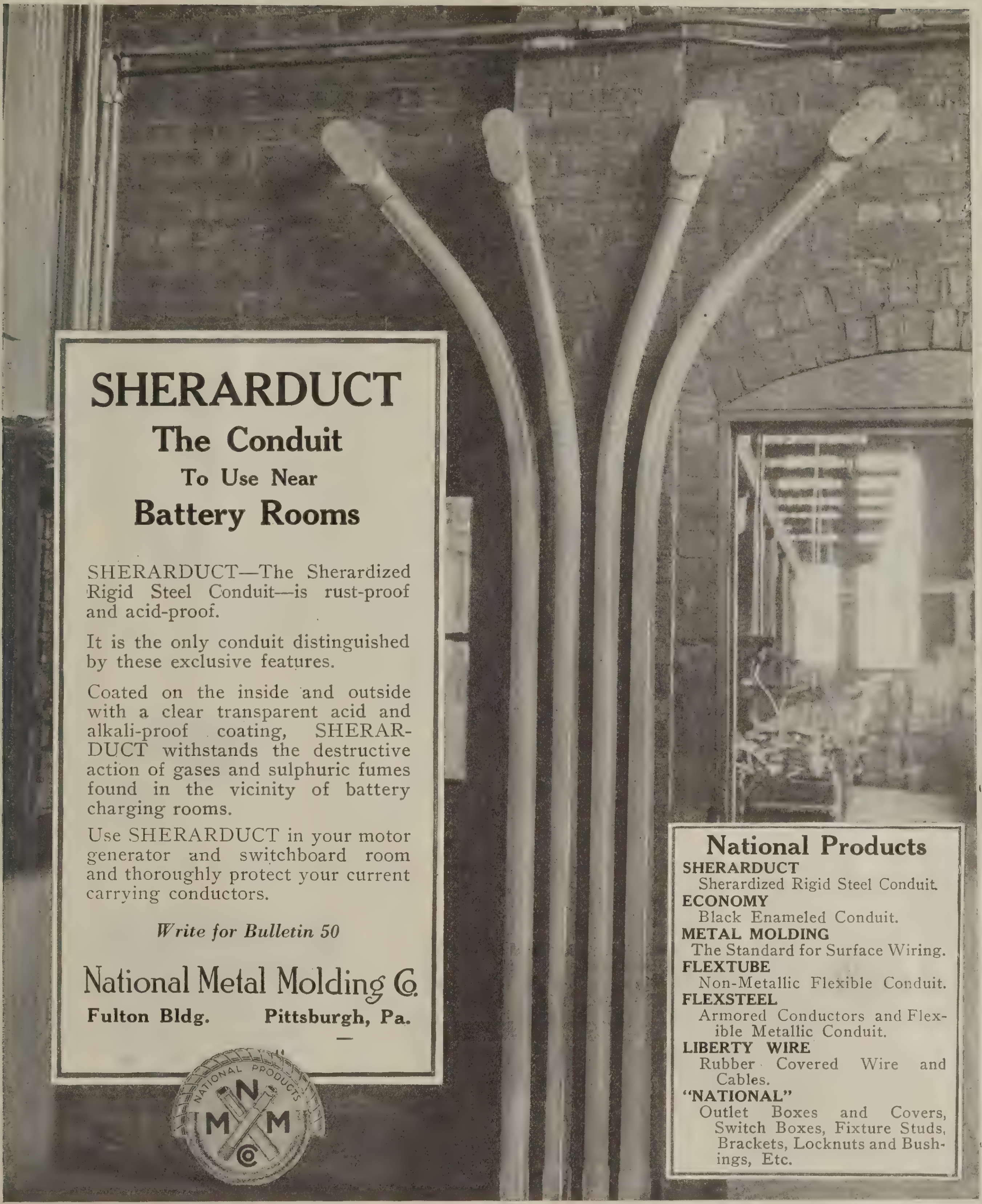
Electrically operated shoe brakes—type "HB"—are bolted to machined lugs on the motor bracket, making a compact unit of motor and brake. All motors are constructed so that the brakes can be mounted on them *without requiring special brake pads.*

Send for Descriptive Leaflet No. 1123

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY
EAST PITTSBURGH, PA.
Sales offices in all large American cities

K1 1071

Westinghouse



SHERARDUCT
The Conduit
To Use Near
Battery Rooms

SHERARDUCT—The Sherardized Rigid Steel Conduit—is rust-proof and acid-proof.

It is the only conduit distinguished by these exclusive features.

Coated on the inside and outside with a clear transparent acid and alkali-proof coating, SHERARDUCT withstands the destructive action of gases and sulphuric fumes found in the vicinity of battery charging rooms.

Use SHERARDUCT in your motor generator and switchboard room and thoroughly protect your current carrying conductors.

Write for Bulletin 50

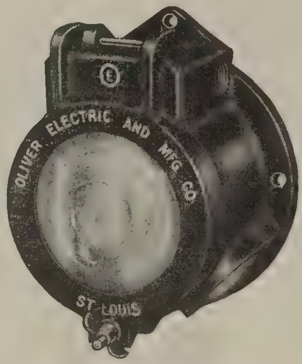
National Metal Molding Co.
Fulton Bldg. Pittsburgh, Pa.

NATIONAL PRODUCTS
N M M Co

National Products

SHERARDUCT
Sherardized Rigid Steel Conduit.
ECONOMY
Black Enameled Conduit.
METAL MOLDING
The Standard for Surface Wiring.
FLEXTUBE
Non-Metallic Flexible Conduit.
FLEXSTEEL
Armored Conductors and Flexible Metallic Conduit.
LIBERTY WIRE
Rubber Covered Wire and Cables.
"NATIONAL"
Outlet Boxes and Covers, Switch Boxes, Fixture Studs, Brackets, Locknuts and Bushings, Etc.

Electrical Appliances for Locomotive Wiring

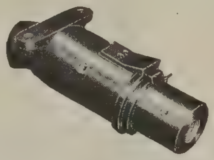


Type T. S. L. Cast Aluminum Tender Signal Lamp

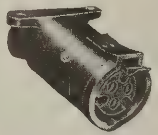
ARRANGED WITH SHUTTER DEVICE FOR RED OR WHITE LIGHT

S. R. B. A. Receptacle
Two-Wire

S. P. Plug with Bushing
for Reinforced Cord

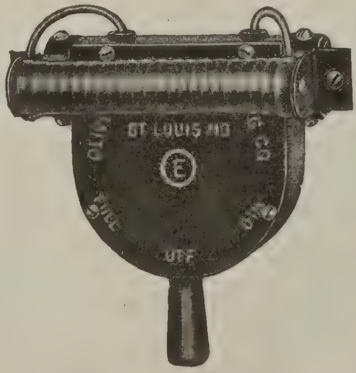


S. R. B. A. Receptacle
With Plug Inserted

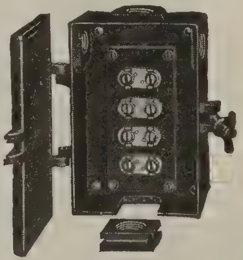


S. R. B. A. Receptacle
Three-Wire

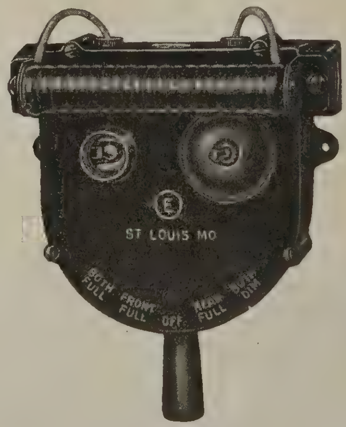
S. P. Plug with Coupling for Flexible Conduit



Type H. S. C. Switch
With Resistance



Type S. T. B.
Terminal Box



Four Position Headlight Switch
Complete with Resistance

OLIVER ELECTRIC & MANUFACTURING COMPANY

ST. LOUIS, U. S. A.

No Rivet Heating Waste Here

No waste of rivets. The boy (or girl) who operates the Berwick Electric Rivet Heater can **see** the rivets being heated. This prevents burning and scaling losses—a saving which averages 40 cents per hundred pounds of rivets heated.

No waste of power. The Berwick uses power only when actually heating rivets—less than 20 kilowatt-hours per hundred pounds of rivets heated. There is no waste of power when the machine is not operated at full capacity.

No waste of labor. Being conveniently portable, and free from smoke and fumes, the Berwick can be placed close to the work, thus eliminating much throwing of hot rivets and sometimes eliminating one boy from each gang.

No waste of time. The men are never kept waiting for hot rivets, for the Berwick will heat a rivet in from 20 to 30 seconds. This eliminates delays when starting work and is especially convenient when only a few rivets are required.

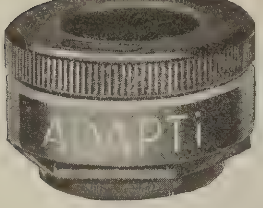
You will be interested in other Berwick features. Send for our catalog. Please mention the quantity and sizes of rivets you use and alternating current conditions.

American Car and Foundry Company

Chicago 165 Broadway, New York St. Louis

BERWICK
ELECTRIC
RIVET HEATER

42



ADAPTi Pipe End Fitting, No. 1300, complete with bushing shown below. Sizes from ½" to 4".

Pipe End Fittings

ADAPTi Time and Money Savers

No. 1200, Threaded composition Bushings, sizes ½" to 4".

ADAPTi Pipe End Fittings fill a distinct need. Behind switchboards and in other places where space does not allow the use of standard fittings, these fittings will serve.

The bushings, made from a practically unbreakable composition, are of unusual mechanical and dialectric strength, with standard pipe thread. They are ideal for use in entrace, cut-out and panel boxes. Standard lock nuts of correct size will lock them in place.

ADAPTi Motor End Fitting No. 4200, sizes ½" to 4".

No. 4300, ADAPTi Motor End Fitting, sizes ½" to 4". As illustrated, they are fitted with porcelain covers with six holes each, two open, four knock-outs. They are flexible, the lugs being interchangeable.

Send for Bulletin which lists ADAPTi Pipe End Findings.

ADAPTi BOXES

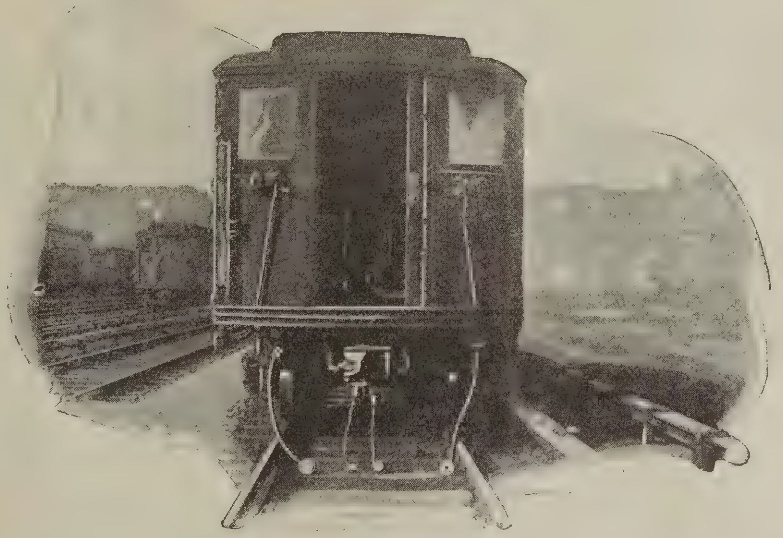
Chicago New York THE ADAPTi COMPANY, CLEVELAND Boston Philadelphia

Trademark U. S. Registered.

HABIRSHAW

"Proven by the test of time"

Insulated Wire & Cable



End of Car for New York Subway Service

Car Jumper Cables

THE four car jumper cables shown in the illustration are for the following purposes (from left to right):

10 conductor cable — Train control, connecting contactors.
4 " " — Electrically controlled brakes.
1 " " — Door Signal for Motorman.
7 " " — Train line Bus.

These are all vital to the successful operation of the trains and are made with a practical realization that the demand for fast, safe and uninterrupted service is imperative.

Habirshaw wires and cables are used by the largest electric railways in the country for all parts of the system.

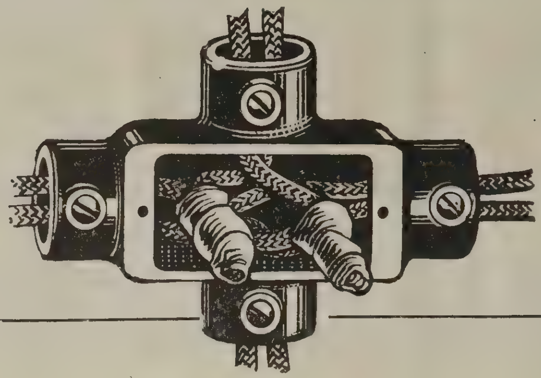
Habirshaw Wire Manufactured by
Habirshaw Electric Cable Co.
Incorporated
Yonkers, New York

Habirshaw Wire Distributed by
Western Electric Company
Incorporated
Offices in All Principal Cities

Paper Insulated Cable
Round Conductor Cables
Sector Cables

Varnished Cambric Insulated Cables
Armored Cables

Rubber Insulated Cables
Code (Black Core)
Intermediate (Red Core)
30% Hevea R.S.A. Standard



Lots of Room for Splices

The form of construction of "Paiste" Taplets leaves room for splices and prevents shorts due to frayed insulation. There are no cover lugs in the side of the fitting to tear insulation as the wires are pulled through.

Every cover fits two sizes of Taplets and each Taplet can be used for many different kinds of outlet fittings. All of which reduces to about a half the stock of Taplets that you need carry.

Write for descriptive data

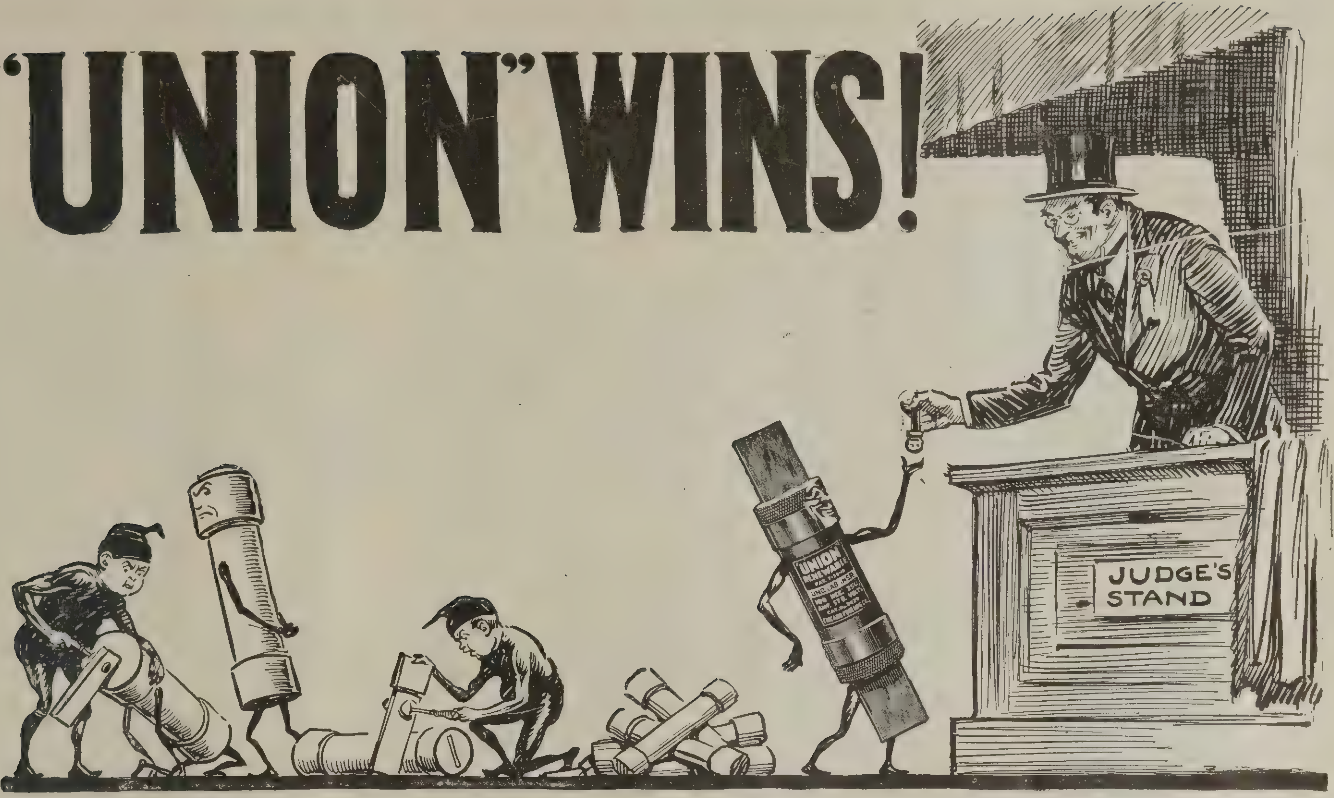
THE HART & HEGEMAN MFG. CO.
HARTFORD, CONN., U.S.A.

"PAISTE"

Taplets

20-13

"UNION" WINS!



Renewed the Quickest and Easiest

If you want to see where a nice little pile of money is wasted, let your men have a "Fuse Renewal" contest. You'll find the link can be removed from a "Union" Renewable and replaced before most fuses can be taken apart.

Perhaps you'll say the difference in time isn't enough to worry about. But figure what this costs in a year at the present high wages.

Then go to your scrap heap and see the bunch of perfectly good fuses that have been thrown away simply because they were so hard to renew that the men didn't bother to replace the blown link. In some plants there is a waste big enough to add a handsome increase to the salary of every employee.

It's different with "Union" Renewables. They're so simple and easy to renew that it is no bother to replace a blown link.

Put "Union" Fuses to any competitive test you like—and we know you will use "Union" exclusively thereafter.

"Union" Fuses, both Renewable and Non-Renewable, for sale by all leading electrical jobbers and dealers. They are approved in the very highest degree by the National Board of Fire Underwriters. Free descriptive booklet sent on request.

"UNION"
RENEWABLE
N. E. C. STD.
PAT. 7-22-19
OTHER PATENTS PENDING
UND. LAB. INSP.
600 AMP.
600 VOLTS
CAT. No. 4247
CHICAGO FUSE MFG. CO.

Chicago Fuse Mfg. Co.

Oldest and largest manufacturers of Fuses, Electrical Protecting Materials and Conduit Fittings

Chicago New York

BY INVITATION MEMBER OF

UNION TRADE MARK

"Here is the *one* renewable Fuse that is fool-proof"

"It will definitely eliminate our dangerous short circuit explosions as well as the burning out of our expensive motors and equipment.

It is fool-proof. I have finally found the only renewable fuse that cannot be overloaded or improperly reloaded intentionally or unintentionally."

Remember—

The National Renewable Fuse is the only Renewable Fuse that has been approved by ALL of the following Insurance Regulating Bodies:

Associated Factory Mutual Fire Insurance Companies
Hydro Electric Power Commission of Ontario, Canada
Millers' Mutual Fire Insurance Companies
Western Factory Insurance Association
Underwriters' Laboratories, Inc.
Mutual Fire Prevention Bureau
Factory Insurance Association

National Fuses
APPROVED-RENEWABLE-POWDER PACKED

Made in Both 250 and 600 Volts up to and including 600 Amperes

The element itself is sealed in a powder-packed renewable cartridge. This powder-packed renewable cartridge slips in the holder like a gun cartridge in a barrel (see illustration above.)

Only one renewable cartridge of the proper size and rating can be inserted at a time, due to its patented design.

National Renewable Fuses are positive and safe in their action—they will guard your electrical circuits accurately, dependably and economically.

Write today for full information and prices, and name of local distributor. Complete stock carried by jobbers and dealers everywhere.

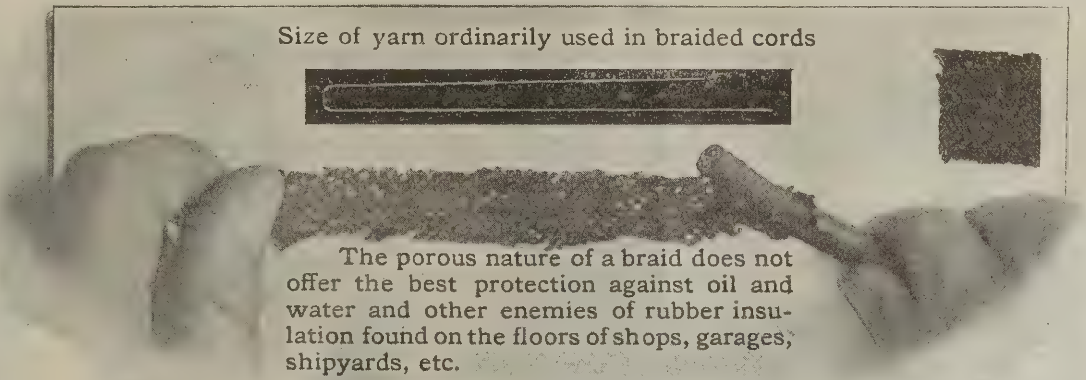
If you have not received your free copy of "Correct Fuse Ratings for Motor Circuits," send for it today

Federal Electric Company
National Renewable Fuse Division
8700 SOUTH STATE STREET CHICAGO, ILL.
91 New Montgomery Street
SAN FRANCISCO, CAL.
627-649 West 43rd Street
NEW YORK, N. Y.
Branches and Distributors in all large cities

THIS cut isn't intended to show the effect of an overdose of current bursting through the cover, but what floor wear does to a braid covered cord designed for pendant use.

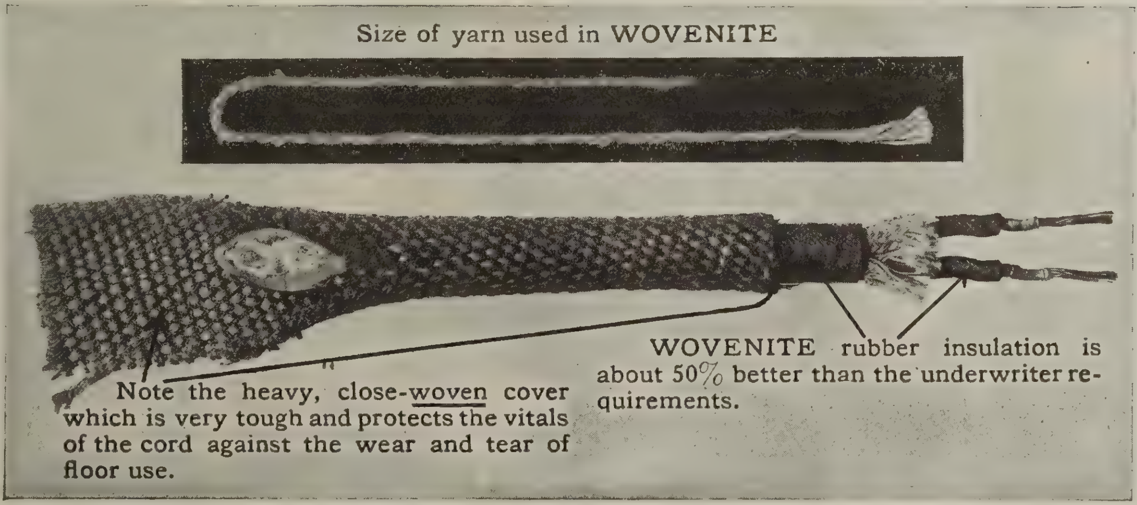
The waste of good material when ordinary cord is used on the floor is something which has been largely overlooked. Just consider the possibilities. Your *overhead* conductors last a *lifetime,* while your braided *floor* cords are often destroyed in a *few weeks.*

THE following cuts illustrate the difference between the texture of WOVENITE hard service *weave* and P.W.P. *braid*—the difference between a weave which will stand the scuffing of thousands of feet on a ship's deck, and a braid composed of cotton thread that unravels whenever cut.



Size of yarn ordinarily used in braided cords

The porous nature of a braid does not offer the best protection against oil and water and other enemies of rubber insulation found on the floors of shops, garages, shipyards, etc.



Size of yarn used in WOVENITE

Note the heavy, close-woven cover which is very tough and protects the vitals of the cord against the wear and tear of floor use.

WOVENITE rubber insulation is about 50% better than the underwriter requirements.

Flexible Woven Cable Company

WOVENITE
REG. U.S. PAT OFFICE

Hardservice Cable for Portable Drills and Lights

172 Purchase Street, Boston, Mass.

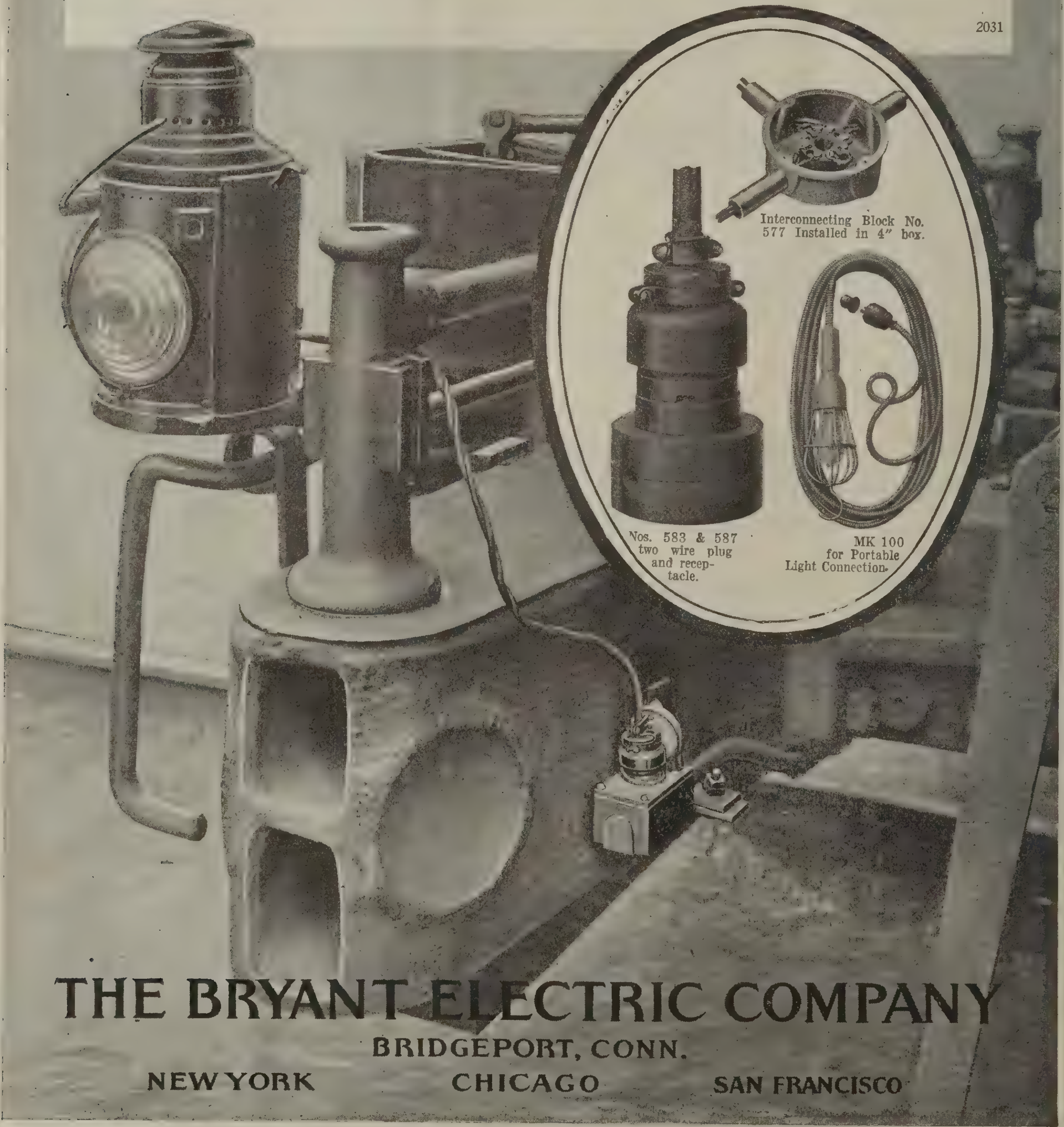
Bryant Railroad Lighting Devices

A railroad wiring device carrying the Bryant Trade Mark is backed by the reputation of the largest exclusive manufacturer of electric wiring devices in the world. It is the result of painstaking study of the requirements of railroad service by engineers who have done nothing all their lives but develop safe, durable and convenient devices.

BRYANT
SUPERIOR WIRING DEVICES

The complete line includes lamp receptacles, snap switches, fuse bases, interconnecting blocks, and "Spartan" plug receptacles and caps, all of which are approved under all codes and by all examining boards. Special precautions have been taken to insure against corrosion and the effects of vibration. Ask our nearest office for complete details.

2031



Interconnecting Block No. 577 Installed in 4" box.

Nos. 583 & 587 two wire plug and receptacle.

MK 100 for Portable Light Connection.

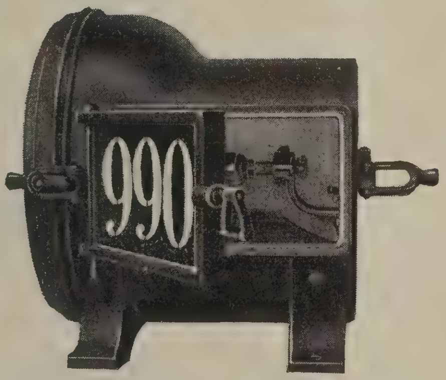
THE BRYANT ELECTRIC COMPANY
BRIDGEPORT, CONN.
NEW YORK CHICAGO SAN FRANCISCO

AMPRO—the *ONE MAN* headlight

Ruggedly Built
of non-corrosive
cast metal

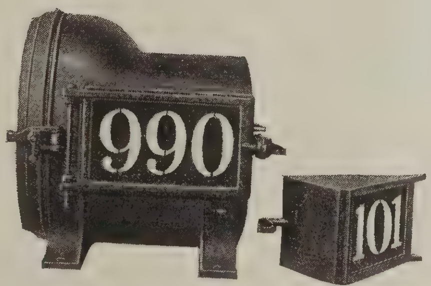
Weighs COMPLETE
approximately
45 pounds

One man can install the AMPRO —no block and fall or special rigging required



New simple, positive focusing device

WATER TIGHT
AIR TIGHT



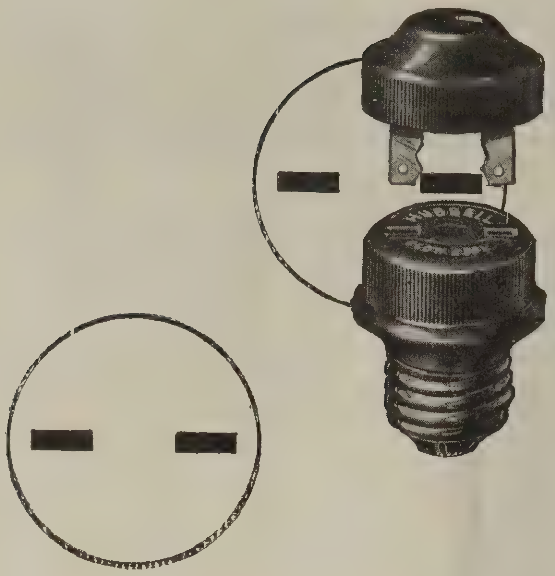
Interchangeable side number doors—angle or straight. Improved latches keep doors intact under severe vibration

American Metal Products Co.

17 Liberty Street **Brooklyn, N. Y.**

GENERAL SALES AGENT:

Sunbeam Electric Manufacturing Co.
(Formerly Schroeder Headlight & Generator Co.)
Evansville, Indiana, U. S. A.
New York Richmond, Va. St. Louis Chicago San Francisco



—so Hubbell combined the slots

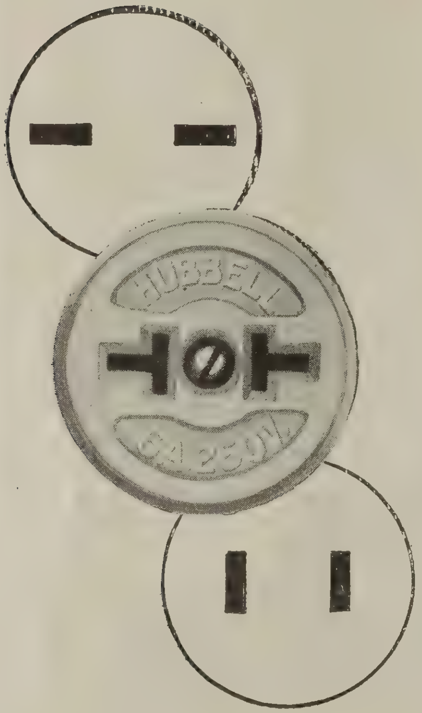
Fifteen years ago Hubbell invented this two-piece Attachment Plug. The Cap has two brass blades: **in size, arrangement and spacing their original dimensions have remained unchanged.**

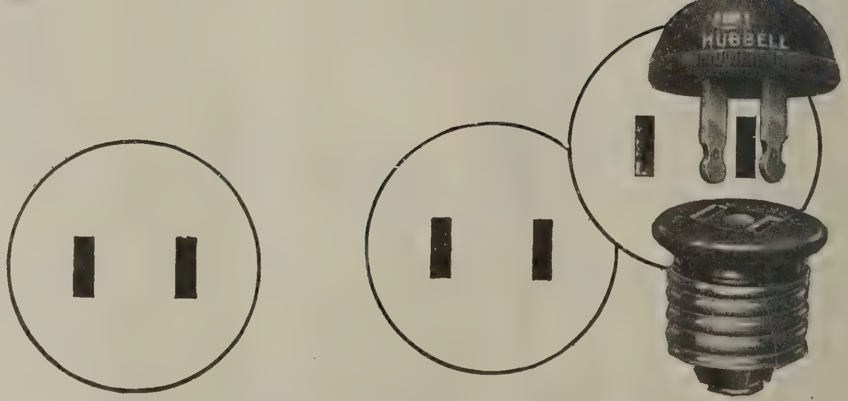
A few years ago, when a somewhat smaller plug was demanded, Hubbell produced the cap with flat **parallel** blades. And here, too, the original dimensions have been consistently followed.

But tandem blades cannot fit parallel slots, neither can parallel blades fit tandem slots. So Hubbell invented the Hubbell T-T Slots.

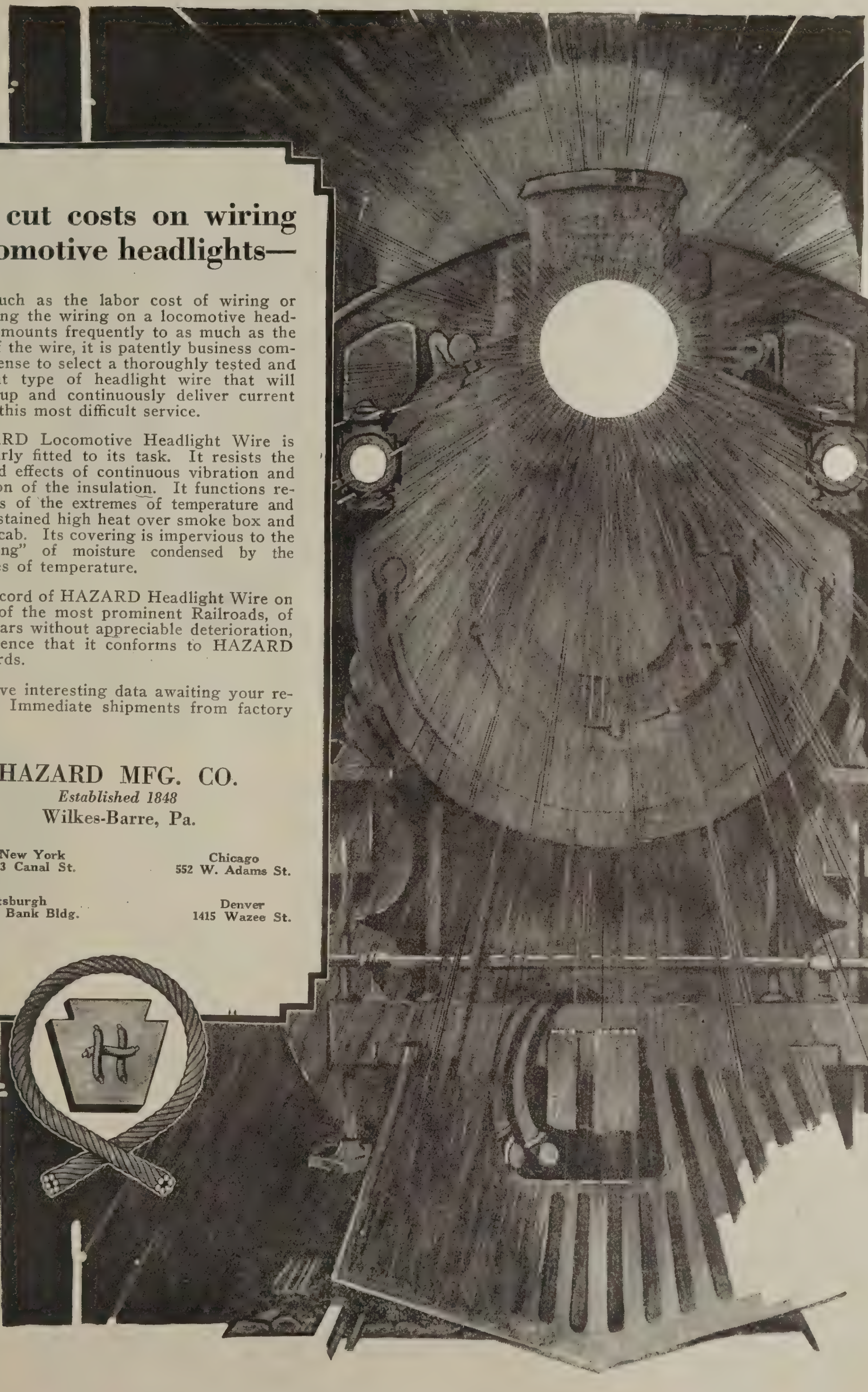
* * * * *

Equip your machines with Hubbell Standard Plugs. Equip your home and shops with Hubbell Standard (T-T Slot) Outlets. By so doing you will have adopted the present electrical standard—and consistent Hubbell practice since 1905. And your electrical devices will be interchangeable.





HARVEY HUBBELL INC
ELECTRICAL SPECIALTIES
BRIDGEPORT CONN, U.S.A.
HUBBELL
REG. U.S. PAT. OFF.



To cut costs on wiring locomotive headlights—

Inasmuch as the labor cost of wiring or renewing the wiring on a locomotive headlight amounts frequently to as much as the cost of the wire, it is patently business common sense to select a thoroughly tested and efficient type of headlight wire that will stand up and continuously deliver current under this most difficult service.

HAZARD Locomotive Headlight Wire is peculiarly fitted to its task. It resists the twofold effects of continuous vibration and abrasion of the insulation. It functions regardless of the extremes of temperature and the sustained high heat over smoke box and in the cab. Its covering is impervious to the "sweating" of moisture condensed by the changes of temperature.

The record of HAZARD Headlight Wire on many of the most prominent Railroads, of two years without appreciable deterioration, is evidence that it conforms to HAZARD standards.

We have interesting data awaiting your request. Immediate shipments from factory stock.

HAZARD MFG. CO.
Established 1848
Wilkes-Barre, Pa.

New York
533 Canal St.

Chicago
552 W. Adams St.

Pittsburgh
1st Nat'l Bank Bldg.

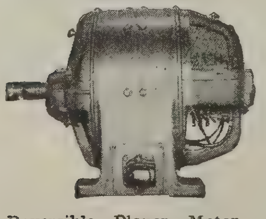
Denver
1415 Wazee St.

The complete electrification of its mechanical units is one of the greatest progressive movements any industry can undertake today

Electric Motors, direct connected to machines, is the most advanced and advantageous method of operation.

Producers! Adjustable Speed Motor direct connected to lathe.

Storage Battery Truck simplifies material handling problems



Reversible Planer Motor—"Makes the chips fly faster."

Electricity concentrates efficiency

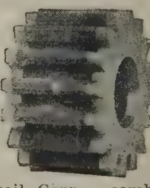
The modern machine shop affords a most striking example of what may be achieved by the electrical operation of its machines and tools.

Nothing is subordinated to power distribution—the machinery is placed in production order, and operated by direct connected electric motors with variable speed control. By this method, compact arrangement of equipment means only concentrated efficiency for all the desirable space is occupied by productive machines.

The electric system also affords a simple and profitable solution of operating trucks, conveyors, furnaces for tool repair, ventilating fans, and like equipment.

A small increase in production will more than balance the initial expense of the electric plant—there is a marked increase in production at every point where electricity is applied—consider the gain in complete electrification.

Good ventilation is imperative—Riveted Frame Induction Motor direct connected to exhaust fan.



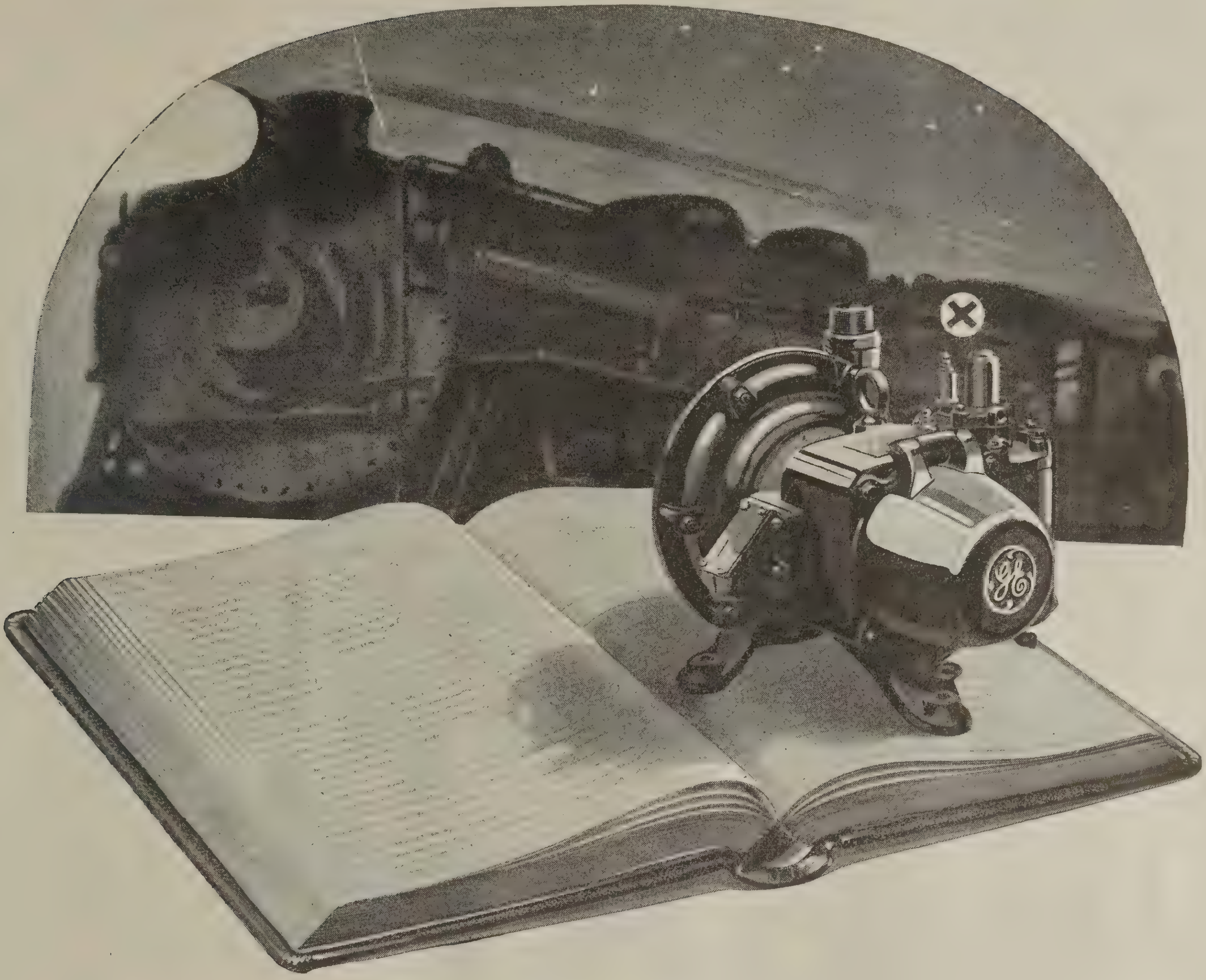
Fabroil Gear — combines durability with silent running.

General Electric Company

General Office
Schenectady, N.Y.

Sales Offices in
all large cities

43B-528



Holding Down Maintenance Cost

As an engineer you are interested in holding down maintenance cost, and we therefore bring to your attention the

G-E Turbine-Generator for Headlights

A device whose fundamental principles of design are radically different from any other type of headlight set.

General Electric Company

General Office Schenectady, N.Y.

28-30

IN the bearings sponsored by **SKF** its type of anti-friction bearings have been developed to their highest perfection. And **SKF** further provides an engineering service not only to assure to itself proper application and use of **SKF** marked products but to help the buyer to fully capitalize the mechanical value built into each device. This service is freely offered and is being continually broadened and advanced by laboratory research that is international in scope. You are assured a similar service behind every product bearing the mark—

SKF

Among these products now offered are:

Single row deep groove ball bearings.
Double row self aligning ball bearings.
Steel balls.
Transmission equipment.

SKF INDUSTRIES, INC.
165 Broadway, New York City

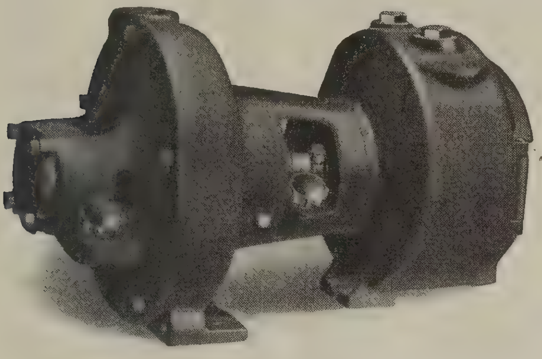
Supervising at the
request of the stockholders
The Hess-Bright Manufacturing Co.
SKF Ball Bearing Co.
Atlas Ball Co.
Hubbard Machine Co.
SKF Research Laboratories

RESEARCH LABORATORY SKF INDUSTRIES INCORPORATED

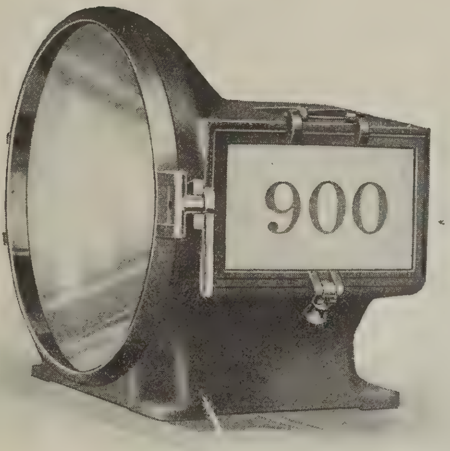
***SKF** Research Laboratory established at Philadelphia to co-operate with the big Gothenburg Laboratories in the study of the American Manufacturers' friction problems.*

C17

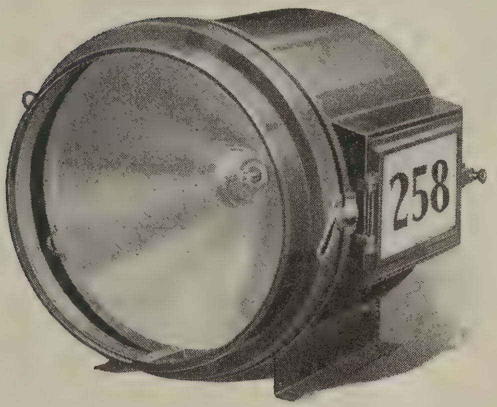
THE outstanding fact is that "Pyle-National" service acts as a body guard and proves the theory that experience counts in producing the best—a characteristic of "Pyle-National" products.



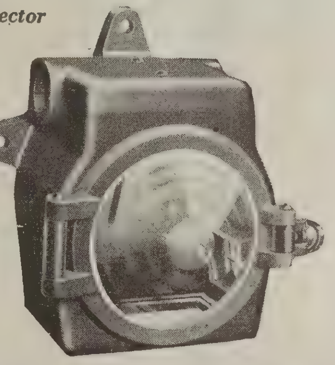
"K-2" Turbo-Generator



Cast Metal Case with Glass Reflector



Standard Incandescent Headlight Case



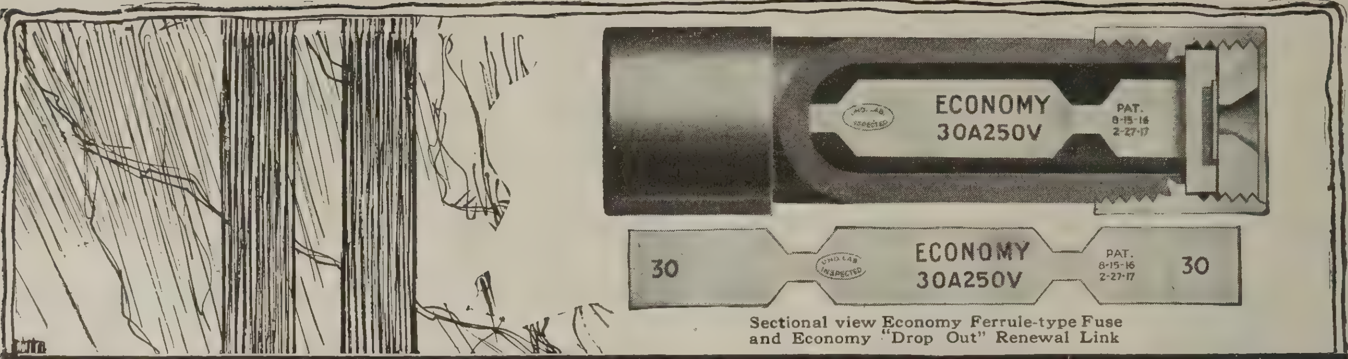
Lamp No. 1095 for Rear of Tender

A Complete Line of Turbo-Generators, Locomotive Headlight Cases, Reflectors and Lighting Accessories.

10" Portable Cast Headlight Case

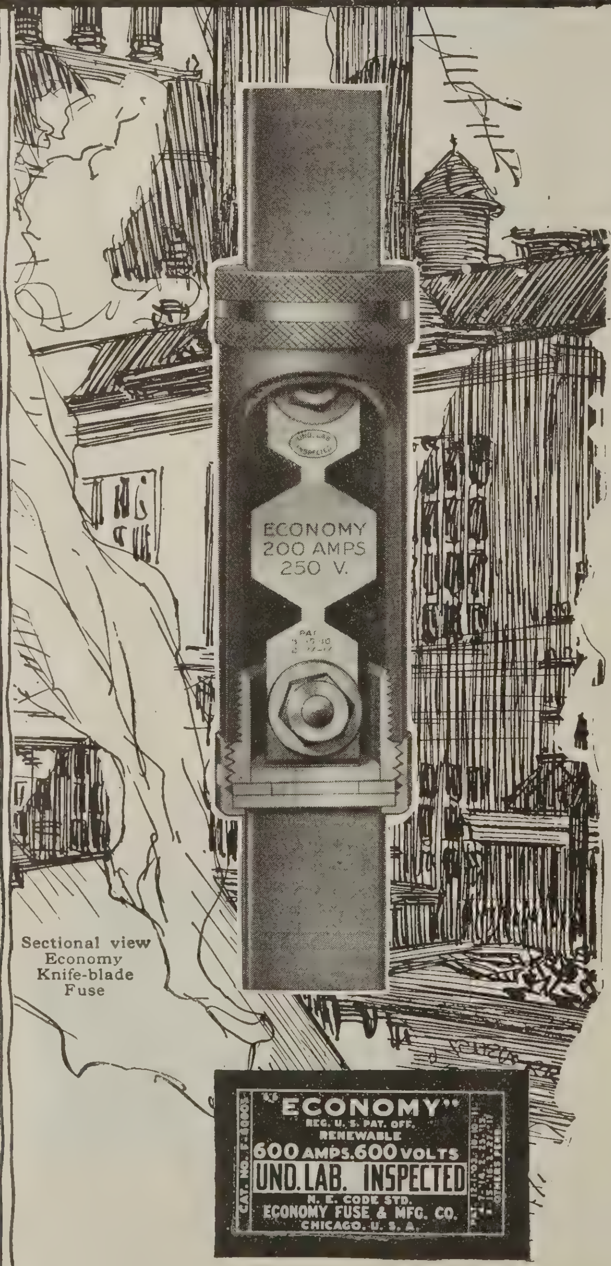
THE PYLE-NATIONAL COMPANY

CHICAGO **NEW YORK**



Sectional view Economy Ferrule-type Fuse and Economy "Drop Out" Renewal Link

ECONOMY *renewable* FUSES



Sectional view Economy Knife-blade Fuse

Consider the Fuses in YOUR Plant

Proper protection of lives, property and machinery in all industrial plants using electrical energy depends upon the accurate functioning of the fuses used.

Economy Fuses are absolutely accurately rated. They operate unfailingly when overloads, short-circuits and lightning discharges cause hazards to lives, apparatus and property.

Nothing is destroyed but the inexpensive strip of fusible metal—quickly and easily replaced by a new Economy "Drop Out" Renewal Link.

This feature cuts annual fuse maintenance costs 80% as compared to the use of one-time fuses.

Avoid production delays; it requires but a minute to restore a "blown" Economy Renewable Fuse to its original efficiency.

Instruct your electrician to install Economy Renewable Fuses at once.

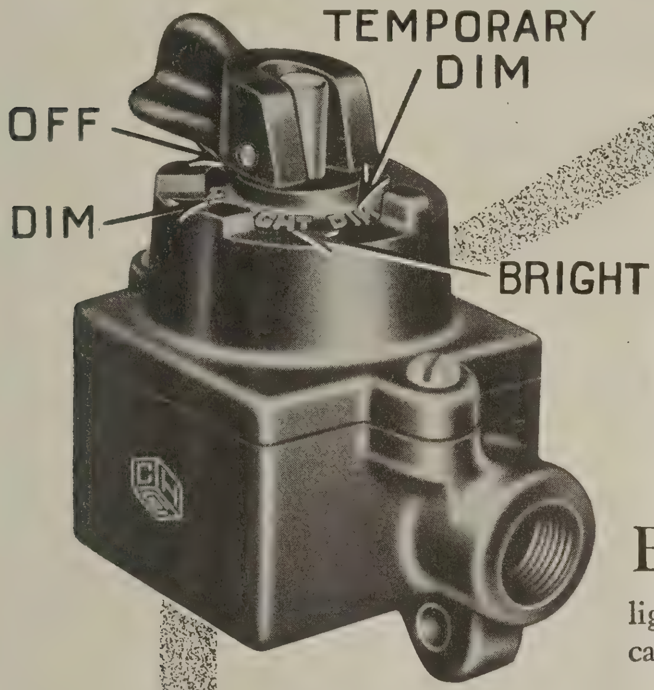
For sale by all leading electrical jobbers and dealers

Economy Fuse & Mfg. Co.
Chicago, U. S. A.

Economy Fuses are also made in Canada at Montreal

Economy Fuses were the first line using an inexpensive bare renewal link for restoring a blown fuse to its original efficiency to be approved in all capacities by the Underwriters' Laboratories

CONDULETS



LH HEADLIGHT SWITCHES
are made in a great many different styles of conduit arrangements.

A Convenient and Simple Headlight Switch

BECAUSE of its compactness, this dust-tight, self-contained Headlight Switch can be conveniently located near the engineer.

All current carrying parts are protected from mechanical injury by the rigid, cast iron housing which excludes cinders and moisture and also assures reliability.

Let us mail you a descriptive Bulletin on LH Switches.

CROUSE-HINDS COMPANY,
SYRACUSE, N. Y.
BOSTON NEW YORK CHICAGO
Condulets Panelboards
Knife Switches Floodlights
Guy Anchors
1586

Condulet the Job

CROUSE-HINDS

A Welcome Christmas Gift For Railroad Men

What will I give him this year? The same old annual problem is here again. Christmas is coming. What can you give him that will be just the thing—a fitting reminder of your friendship—a token of your thoughtfulness.

If your friend is a railroad man, a year's subscription to The Railway Electrical Engineer will solve the problem for you. Twelve separate presents—each one a reminder of you. He will enjoy receiving the twelve issues brimful of ideas, and you will have the satisfaction of knowing that you have given him something to help him during the coming year.

Best of all it does not require any shopping or detailed effort. Simply fill in the name of your friend on the attached coupon and mail to us with your remittance.

Then in his Christmas mail your friend will receive a personal letter from us saying that you have ordered The Railway Electrical Engineer sent to him for a year and that you wish him A MERRY CHRISTMAS and A HAPPY NEW YEAR.

And beginning with the January, 1921 issue The Railway Electrical Engineer will go to your friend each month for twelve months.

The subscription price is $3.00 a year—small compared to the value received.

Decision is only the matter of an instant. Fill in the coupon now—while the thought is fresh in your mind and send to us at once.

TEAR OFF THE COUPON HERE—AND MAIL IT

Publisher of The Railway Electrical Engineer.
Woolworth Bldg., New York

Date..1920

Please send The Railway Electrical Engineer for one year, beginning with the January, 1921 number, and write a personal letter at Christmas time to:

Name ....Street ....

Town ....State ....

I enclose check—draft—money order—currency for $.......?

Name ....

Address ....

Out of the experienced past,
into the exacting present,
KERITE through more than
a half-century of successful service, continues
as the standard by which
engineering judgment
measures insulating value

DAYS KERITE

KERITE INSULATED WIRE & CABLE COMPANY
NEW YORK CHICAGO

Lillibridge 80-365

Fairbanks-Morse Ball Bearing Motors

Your Meter Will Prove Ball Bearing Economy

Cut friction losses and you make current savings. Fairbanks-Morse Ball Bearing motors require little attention—they run smoothly and continuously over long periods. The ball bearings are packed in grease—no oil drip.

The solid jointless rotor winding, first introduced in Fairbanks-Morse motors, gives high electrical conductivity and mechanical strength. End rings cast on solid copper bars—no arcing or sparking.

Fairbanks-Morse Ball Bearing motors are daily making records of economical and continuous operation in every industry.

FAIRBANKS-MORSE QUALITY
F M
100%

Fairbanks, Morse & Co.
MANUFACTURERS CHICAGO

Oil Engines - Pumps - Electric Motors and Generators - Fairbanks Scales - Railway Appliances - Farm Power Machinery

A NATIONAL ELECTRICAL SERVICE FOR RAILROADS

THE Western Electric Company with houses in forty-eight principal cities occupies an enviable position as a source for every electrical supply used by railroads.

Pole Line Material, Sunbeam Mazda Lamps, Flood Lights, Wiring Devices, Wire, Electrical Tools, and everything electrical is carried in our stocks.

For prompt service get in touch with the Western Electric House nearest you.

Western Electric Company
Offices in All Principal Cities

Western Electric

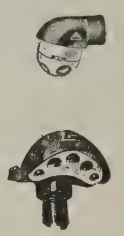
APPLETON PRODUCTS
for
electrical installations

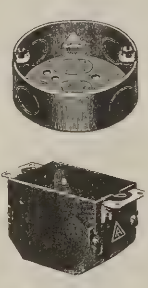
THE fittings illustrated on this page are representative of the Appleton Products but a complete and comprehensive listing will be found in large catalog and supplementary bulletins.

"Unilets" and majority of Appleton Products are made from steel which insures greater wiring space in addition to which they are much lighter in weight thereby making them easier to handle.

"UNILETS"
"Reg. U. S. Pat. Off."

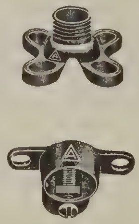
Steel Conduit Fittings


"APPLETON"
Entrance Fittings


"APPLETON"
Outlet Boxes and Covers, and Switch Boxes

"APPLETON"
Conduit Clamps and Hangers

"APPLETON"
Locknuts and Bushings


"APPLETON"
Fixture Stems and Ground Clamps

Appleton Products Include

- "UNILETS"
- Outlet Boxes and Covers
- Laundry Fittings
- Locknuts and Bushings
- Meter Terminal Fittings
- Conduit Clamps and Hangers
- Entrance Fittings
- "Pagrip" Metal Molding and Fittings
- Switch Boxes
- "A Fitting for Every Requirement"

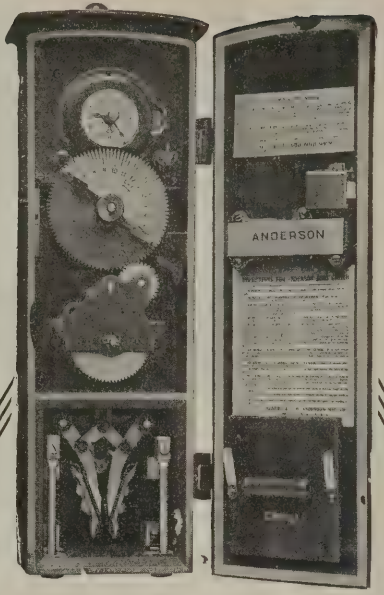
Write for catalog and bulletins giving complete listing of above products

APPLETON ELECTRIC COMPANY
Factory and General Offices
227 N. Jefferson St., Chicago

New York
55 Barclay Street

St. Louis
917 Pine Street

San Francisco
509 Mission Street



Anderson Automatic Time Switches

Eliminate the human element. Much power can be saved on your system by the installation of Anderson Automatic Time Switches on your yard lights, platform lights, etc., which open and close your circuits at a set time with absolute precision.

These switches protect you against forgetful, inattentive and inaccurate service from your men.

Anderson Automatic Time Switches now in service are eminently satisfactory to the users.

Albert & J. M. Anderson Mfg. Co.
289-305 A Street, Boston, Mass.

NEW YORK—135 Broadway
PHILADELPHIA—429 Real Estate Trust Bldg.
CHICAGO—105 S. Dearborn Street

O-B Signal Bond—Patented

A 7-inch length of No. 1 B. & S. Gauge Copper Strand. On each terminal is a steel sleeve.

The bond is gas welded to the rail.

Improvement Is Evident the Day O-B Signal Bonds Go On the Track

As soon as the last O-B Signal Bond is installed, tests show marked improvements in the track circuit.

These immediate results are so satisfactory that enthusiasm—and action—has invariably followed a trial installation.

One road installed O-B Bonds on a mile and placed an order at once for enough to cover 10 miles. Another line tried O-B Bonds on one signal section and is now planning to put them on a 40 mile stretch of track.

"Improving the Track Circuit" tells the story of O-B Signal Bonds. Have you a copy?

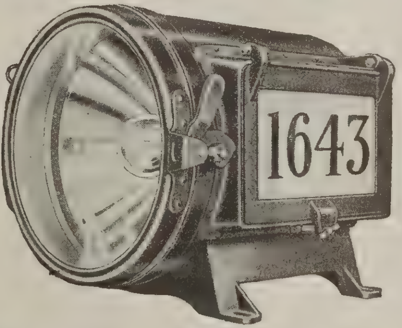
The Ohio Brass Company

Mansfield, Ohio

New York Philadelphia Pittsburgh Chicago
San Francisco Los Angeles Paris, France

KEYSTONE

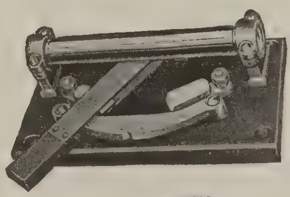
Locomotive Headlight Equipment



"Golden Glow" Headlight

The Golden Glow Headlight

has a ground, mirror glass reflector. This reflector will never tarnish and will never require repolishing—they retain their initial high efficiency for years. The cleaning of this reflector is done by wiping with a rag.



"Keystone" Headlight Switch

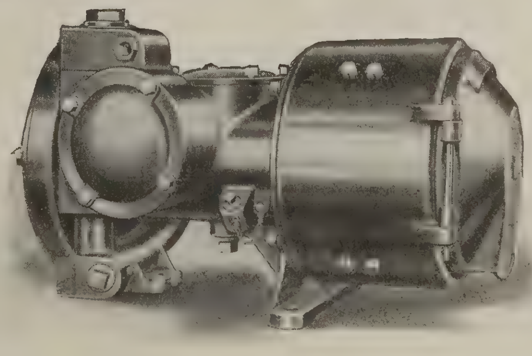
The Keystone Headlight Switch

consists of a heavy blade operating in a plane parallel with and close to the base. All parts are durable and accessible—they're built for rough usage.

The Keystone Turbo-Generator

has a valve and speed adjustment that requires inspection only about once a year. The improved lubrication system necessitates a complete oil change but once in about six months. The generator supplies a remarkably even voltage under wide variation of pressure and load—their maintenance cost is unusually low.

Write for Bulletin No. 166



"Keystone" Turbo-Generator

ELECTRIC SERVICE SUPPLIES CO.

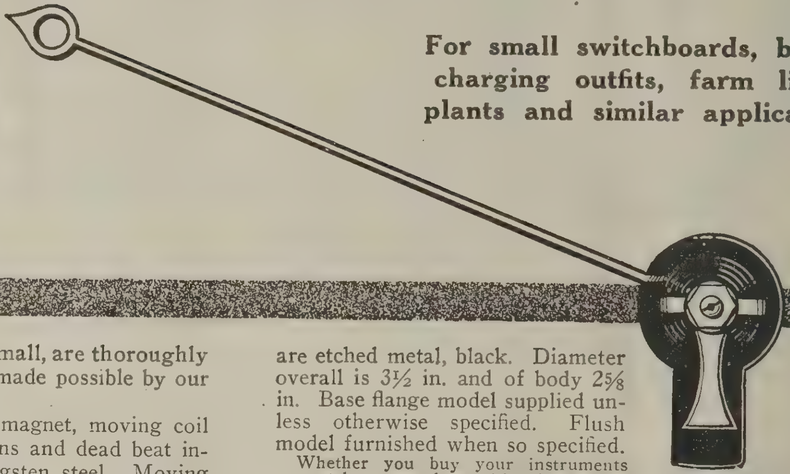
Railway Material and Electrical Supplies

PHILADELPHIA, 17th and Cambria Sts.
NEW YORK - - - - - 50 Church St.
CHICAGO - - - - Monadnock Bldg.

ROLLER-SMITH

TYPE TID (formerly Junior Imp)
DIRECT CURRENT AMMETERS AND VOLTMETERS

For small switchboards, battery charging outfits, farm lighting plants and similar applications.



These little instruments, while small, are thoroughly good. Their low prices have been made possible by our extremely heavy production.

Mechanism is of the permanent magnet, moving coil type, insuring uniform scale divisions and dead beat indications. Magnets are forged tungsten steel. Moving element is light but rigid. Case is heavy brass with black rubberoid finish and is dust and moisture proof. Dials are etched metal, black. Diameter overall is 3½ in. and of body 2⅝ in. Base flange model supplied unless otherwise specified. Flush model furnished when so specified.

Whether you buy your instruments separately or get them with other equipment, **specify Roller-Smith** Type TID, *and insist that you get them.*

Send for Bulletin Y-400 which covers the line. Address point nearest you.

BALTIMORE, 113 E. Franklin St.
BIRMINGHAM, Brown-Marx Bldg.
BOSTON, 141 Milk St.
BUFFALO, 707 Ellicott Sq.
DALLAS, 2002½ Live Oak St.
DENVER, 1710 Glenara St.
LOS ANGELES, Title Insurance Bldg.
MINNEAPOLIS, 414 South 6th St.

ROLLER-SMITH COMPANY
Electrical Instruments, Meters and Circuit Breakers

MAIN OFFICE:
2 Park Place, New York

ROLLER SMITH

WORKS:
Bethlehem, Pennsylvania

CHICAGO
Monadnock Block

CLEVELAND
6523 Euclid Ave.

DETROIT
Majestic Bldg.

MONTREAL, Power Bldg.
PHILADELPHIA, Drexel Bldg.
PITTSBURGH, Union Arcade Bldg.
ST. LOUIS, Railway Exchange Bldg.
ST. PAUL, Pioneer Bldg.
SALT LAKE CITY, 59 West Broadway.
SAN FRANCISCO, 589 Howard St.
SEATTLE, 524 First Ave., So.
TORONTO, 183 George St.

A TOOL THAT YOU NEED

You may be able to do a job without the proper tools, but you could do it quicker and easier if you used the right equipment. Did you ever think of the RAILWAY ELECTRICAL ENGINEER as a tool that will help you—not only in making today's job easier to handle, but also in fitting you for the bigger jobs ahead?

The RAILWAY ELECTRICAL ENGINEER gives you the benefit of the best experience and knowledge in the field; it keeps you posted on all new equipment and devices put on the market; it prepares you for the advancement that is yours if you are ready for it. And all for $3.00 a year.

You ought to have your own copy of the RAILWAY ELECTRICAL ENGINEER if you are to get the most good from it. You should read it and study its pages thoroughly. More than that, you should keep it. In no other way can you preserve so much valuable information for future use.

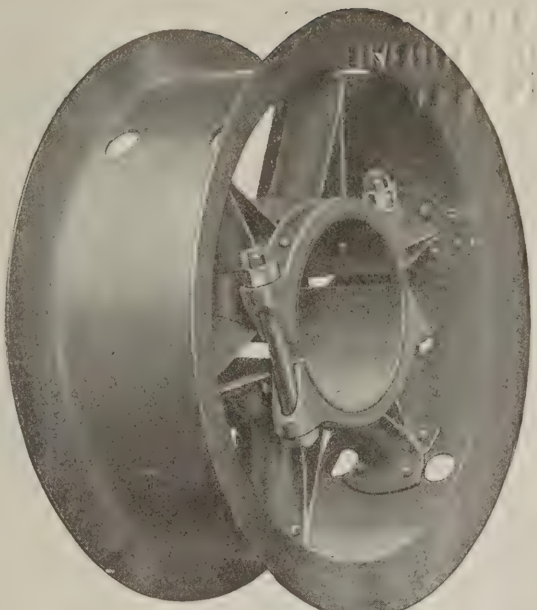
Write your name and address in the margin of this page, tear it out, and send it to us with **your check or money order** for a year's subscription. Do it now!

RAILWAY ELECTRICAL ENGINEER
Woolworth Building **New York City**

A reliable pulley for car lighting

Car axle lighting pulleys must run in sand and mud in summer, in ice, slush and snow in winter. They must withstand jolts and jars of rough road beds at all seasons.

To give satisfactory service under these severe conditions requires an exceptionally strong pulley and a bushing that will positively prevent it from slipping on the axle.

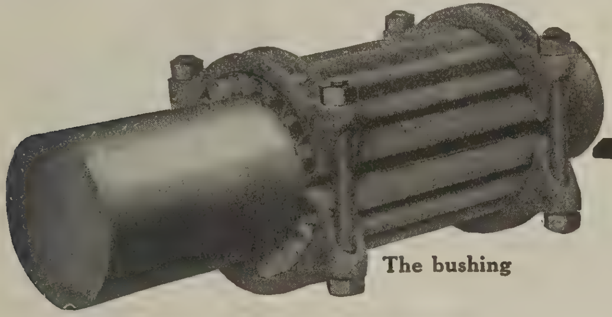


The pulley

The Keystone car lighting pulley with Oneida corrugated bushing

The combination of Keystone steel pulley and Oneida corrugated steel bushing is standard with many of the best car builders in America.

The design of the pulley and the materials from which it is made insure maximum strength and endurance.



The bushing

The bushing fits either straight or tapered axles. It grips the axle firmly under all conditions.

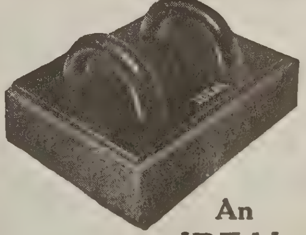
Write us for full information regarding this practical combination.

Dodge Sales and Engineering Co.,
Oneida, N. Y., U. S. A.
Distributor of the Products of Dodge Mfg. Co. and Dodge Steel Pulley Corporation
Originators of Steel Railroad Pulleys and Steel Corrugated Bushings

---

Grind Down Your Commutators in Place

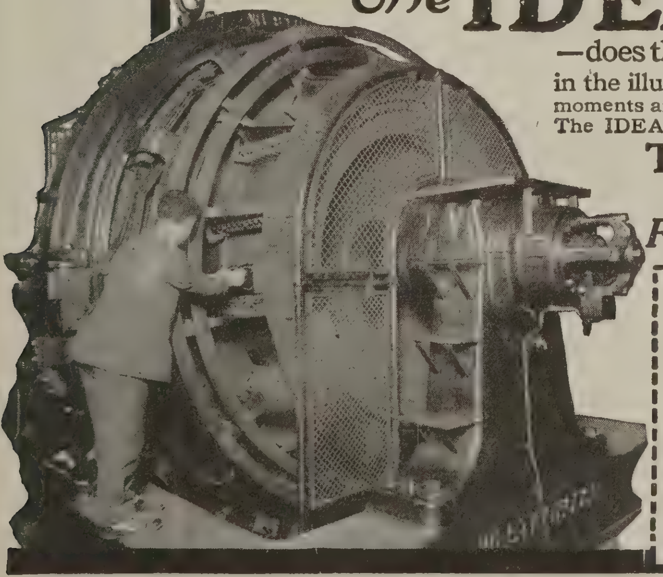
—with an abrasive tool—a manufactured composition in block form which when held against revolving commutators, grinds down irregularities and stops sparking and loss of power.



An IDEAL

The IDEAL COMMUTATOR RESURFACER

—does the trick. An occasional application, as shown in the illustration, stops sparking and loss of power in a few moments and saves many dollars spent for resurfacing by other methods. The IDEAL never clogs and always cuts evenly.



Try One Out Without Cost

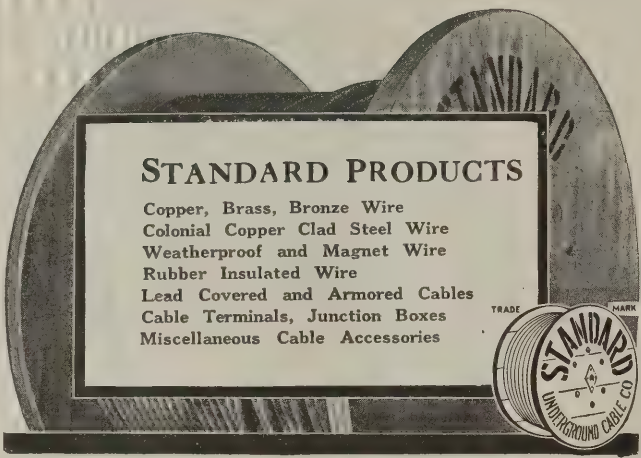
Our Free Trial Plan is explained on the Coupon.

Fill It Out and Mail It Today!

IDEAL COMMUTATOR DRESSER CO.,
3227 Sheffield Avenue, Chicago (REE-12-20)

Gentlemen:—Please send me an Ideal Commutator Resurfacer for 10 days' free trial. If I am not fully satisfied with it I will return it collect at no expense to me. If at the end of ten days I am fully satisfied with it, you may bill us for the resurfacer. I want to use it on equipment as follows:

Approx. R. P. M.......................... Diameter of Commutator or Ring..................
Approx. width of Commutator or ring surface ....
Approx. distance between brush sets............................ Condition..................
Ring material (copper, steel, etc.)..
My name is...Position.........................
Company.......................................Company address...........................
City.. State...................................



STANDARD PRODUCTS

Copper, Brass, Bronze Wire
Colonial Copper Clad Steel Wire
Weatherproof and Magnet Wire
Rubber Insulated Wire
Lead Covered and Armored Cables
Cable Terminals, Junction Boxes
Miscellaneous Cable Accessories

PURCHASERS of STANDARD Products receive the benefit of our 38 years experience devoted exclusively to the manufacture and installation of electric wires and cables.

This experience, together with unexcelled manufacturing and shipping facilities, enables us to meet your every requirement, however large, promptly and satisfactorily.

Write our nearest office about your requirements.

Standard Underground Cable Co.
Pittsburgh, Pa.

New York
Boston
Washington
Atlanta
Philadelphia
San Francisco
Detroit
Chicago
St. Louis
Seattle
Los Angeles

The Symbol of Service

SERVICE which blocks against unnecessary expenditure and trouble, which—by enabling you to *know* that the electrical goods you buy will deliver the service they should, *increases the purchase power of your dollars.*

Exactly—that is what this symbol means to a large clientele the country over.

Interested? Then send for our booklet—*"The Testing Service"*—a guide to Greatest Purchasing Efficiency at Moderate Cost.

ELECTRICAL TESTING LABORATORIES
80th St. and East End Ave., New York

THE
"A" "B" "C"
ALEX. R. BENSON COMPANY, INC.
HUDSON, N. Y.
OF THE

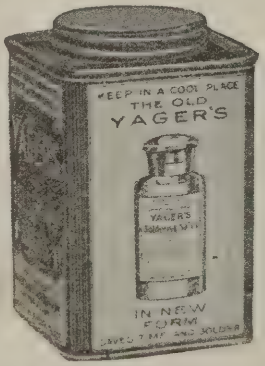
Soldering Salts Business

was contemporary with our introduction to it almost 50 years ago, when resin, and soldering "acid" were about the only fluxes in use, but today the name

"YAGER'S"

is your assurance that you are getting the results of a half-century of effort toward a definite object.

Buy from your jobber in ½ lb. 1 pound and 5 lb. blue and white enameled cans; if he does not handle, write us for prices.



CLASSIFIED ADVERTISEMENTS

EMPLOYERS—Send us your inquiries for men of technical training and experience. We are obtaining employment for soldiers, sailors and marines released from service. Re-Employment Bureau of New York City for Soldiers, Sailors and Marines, 505 Pearl Street, north of Municipal Building, Professional Section, Worth 9250.

A classified advertising section will be incorporated in this publication whenever necessary.

Use this service when seeking a new man, a new position, or when buying or selling second-hand equipment.

Rate is 5c. a word a month. Minimum charge $1.00. Remittance must accompany each order. Address Railway Electrical Engineer, Classified Advertising Department, Woolworth Building, New York, N. Y.

The "Alternarc" 100 Pound Welding Machine

This machine is especially adapted to the class of welding done in Machine, Plumbing and Sheet Metal Shops and is an efficient and speedy worker.

While we do not recommend this type for the heavier welding duties done by the larger "Alternarc" type, it will do this work in emergencies.

We manufacture other types to meet any condition.

"Newarc" Welding Accessories

consisting of highest quality Electrodes, Holders, Helmets, Aprons, Gloves, etc.

Let our engineers give you information on "Alternarc" welding.

Write for descriptive literature—Series C.

The Electric Arc Cutting & Welding Co.

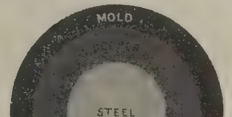
152 JELLIF AVE. **NEWARK, N. J.**

Branches:

Pittsburgh
Cincinnati
Chicago
Cleveland
St. Louis
Detroit
New Orleans
Philadelphia
Montreal
Indianapolis

"ALTERNARC"
CUTTING and WELDING

EA-7



"COPPERWELD"

TRADE MARK REG. U. S. PAT. OFF.

Putting the Strength of Steel Into Your Wires

"Copperweld" is made by casting molten copper about a specially treated round billet, carefully centered in a round mold. The composite billet is subsequently hot rolled to a wire rod, and then cold drawn to "Copperweld" Wire—the copper conductor with the strength of steel.

The coextension of the two metals is equal, and the per cent of coating remains the same at all stages of manufacture.

Bend, twist, stretch, and break "Copperweld"—you will find that the copper coating is practically homogeneous with the steel core.

From the raw steel and virgin copper, from which the wire is made, every process in the manufacture of finished "Copperweld" is performed by skilled workmen, under our own supervision, in our own shops. This assures exact and dependable results.

"Copperweld" is 50% stronger than either galvanized or copper wire of the same section.

Size for size, "Copperweld" is from 7% to 10% lighter than copper wire. "Copperweld" costs less per pound than copper wire.

Our engineering department will be glad to offer recommendations which will aid in the logical solution of your wire problems, and quotations together with literature will be submitted promptly upon request.

Write for Catalogue No. 31.

COPPER CLAD STEEL COMPANY

ARISTOS COPPERWELD

OFFICE AND WORKS: RANKIN, PA. BRADDOCK P. O.
NEW YORK CITY OFFICE: 30 CHURCH ST.
WESTERN SALES REPRESENTATIVES: STEEL SALES CORPORATION, CHICAGO, ILL.

Model 310 Single-phase Portable A.C. and D.C. Watt-meter.

Weston

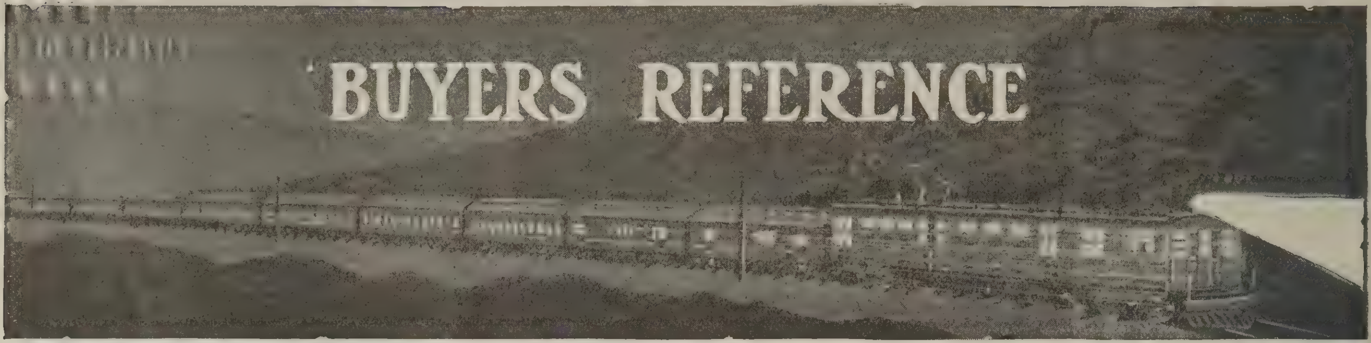
Electrical Indicating Instruments

Are used throughout the civilized world, wherever the art of Electrical Measurement attains its highest perfection. A.C. or D.C. Switchboard or Portable Instruments for every field of Indicating Electrical Measurement.

In writing for catalog or bulletin, please specify the field that interests you.

WESTON ELECTRICAL INSTRUMENT CO.

93 Weston Ave., Newark, N. J.



BUYERS REFERENCE

AMMETERS
Roller Smith Co.
Weston Electrical Instrument Co.

ARC WELDING EQUIPMENT
Electric Arc Cutting & Welding Co.
General Electric Co.
U. S. Light & Heat Corp.
Westinghouse Electric & Mfg. Co.

ARRESTORS, LIGHTNING
Electric Service Supplies Co.
General Electric Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.

AXLE PULLEYS
Dodge Sales & Engineering Co.

AXLE PULLEY BUSHINGS
Dodge Sales & Engineering Co.

BATTERIES, STORAGE
Edison Storage Battery Co.
Electric Storage Battery Co.
Gould Coupler Co.
Safety Car Heating & Lighting Co.
Western Electric Co.
U. S. Light & Heat Corp.
Willard Storage Battery Co.

BATTERY CHARGING APPARATUS
Anderson Mfg. Co., Albert & J. M.
Cutler-Hammer Mfg. Co.
General Electric Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.

BEARINGS, AXLE GENERATOR
Fafnir Bearing Co.
Oliver Electric & Mfg. Co.
S. K. F. Industries, Inc.

BEARINGS, BALL
Fafnir Bearing Co.
S. K. F. Industries, Inc.

BEARINGS, BALL THRUST
Fafnir Bearing Co.
S. K. F. Industries, Inc.

BELTING, AXLE GENERATOR

BONDS, RAIL
Copper Clad Steel Co.
Electric Service Supplies Co.
General Electric Co.
Ohio Brass Co.
Westinghouse Electric & Mfg. Co.

BOND TESTERS, RAIL.
Roller-Smith Co.

BOXES, CABLE JUNCTION
Standard Underground Cable Co.

BOXES, CONDUIT OUTLET
American Metal Products Co.
Central Electric Co.
National Metal Molding Co.

BOXES, SWITCH
Appleton Electric Co.
Adapti Co.
Central Electric Co.
Crouse-Hinds Co.

BRAKES, ELECTRIC
Cutler-Hammer Mfg. Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

BRUSHES, GENERATOR
National Carbon Co.

CAB LIGHTING FIXTURES
Appleton Electric Co.
Central Electric Co.
Crouse-Hinds Co.
Oliver Elec. & Mfg. Co.

CABINETS
Central Electric Co.
Hart & Heglman Mfg. Co.

CABLE, ARMORED AND LEAD COVERED
Anaconda Copper Mining Co.
Central Electric Co.
General Electric Co.
Hazard Mfg. Co.
Kerite Insulated Wire & Cable Co.
Standard Underground Cable Co.
Western Electric & Mfg. Co.

CABLE, INSULATED
Anaconda Copper Mining Co.
Central Electric Co.
General Electric Co.
Habirshaw Electric Cable Co., Inc.
Hazard Mfg. Co.
Kerite Insulated Wire & Cable Co.
Standard Underground Cable Co.

CABLE, TELEPHONE
Anaconda Copper Mining Co.
Central Electric Co.

CABLE TERMINALS
Electric Service Supplies Co.
Standard Underground Cable Co.
Western Electric Co.

CAR LIGHTING EQUIPMENT
Electric Storage Battery Co., The
Gould Coupler Co.
Safety Car Heating & Lighting Co.
Stone Franklin Co.
U. S. Light & Heat Corp.

CAR LIGHTING FIXTURES.
American Metal Products Co.

CAR LIGHTING GENERATORS
Stone Franklin Co.

CAUSTIC SODA CELLS
National Carbon Co.

CHARGING PLUGS & RECEPTACLES
Central Electric Co.

CIRCUIT BREAKERS, CARBON
General Electric Co.
Roller Smith Co.
Westinghouse Electric & Mfg. Co.

CIRCUIT BREAKERS, OIL
General Electric Co.
Westinghouse Electric Co.

CLUTCHES, MAGNETIC
Cutler-Hammer Mfg. Co.

COMMUTATOR BLOCKS
Ideal Commutator Dresser Co.

COMPRESSORS, AIR
General Electric Co.

CONDUIT FITTINGS
Adapti Co.
Appleton Electric Co.
Central Electric Co.
Chicago Fuse Mfg. Co.
Crouse-Hinds Co.
Hart & Heglman Mfg. Co.

CONDUIT, FLEXIBLE METALLIC
Central Electric Co.
National Metal Molding Co.

CONDUIT, RIGID
Central Electric Co.
National Metal Molding Co.

CONNECTORS
Westinghouse Elec. & Mfg .Co.

CONNECTORS, SOLDERLESS
Westinghouse Elec. & Mfg. Co.

CONTROL APPARATUS
Safety Car Heating & Lighting Co.

COPPER RODS AND TUBES
Standard Underground Cable Co.

CUTOUTS, ENTRANCE
Appleton Electric Co.
Chicago Fuse Mfg. Co.
Crouse-Hinds Co.
Hart & Heglman Mfg. Co.

CUTOUTS, PLUG AND PANEL
Crouse-Hinds Co.
Chicago Fuse Mfg. Co.

DRY BATTERIES
National Carbon Co.

DYNAMOS
Stone Franklin Co.

ELECTRIC GENERATORS
Stone Franklin Co.

ELECTRIC SIGNS
Federal Electric Co.

ELECTRICAL APPARATUS AND SUPPLIES
Central Electric Co.
Electric Service Supplies Co.
General Electric Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.

ELECTRIFICATION CONSTRUCTION MATERIALS
Ohio Brass Co.

ELECTRIFICATION OF STEAM ROADS
General Electric Co.
Westinghouse Electric & Mfg. Co.

ELECTRODE
National Carbon Co.
Reid-Avery Co.

FANS, CAR
Central Electric Co.
General Electric Co.
Safety Car Heating & Lighting Co.
Westinghouse Electric Mfg. Co.

FANS, DESK AND BRACKET
Central Electric Co.
General Electric Co.
Western Electric Co.
Westinghouse Electric Mfg. Co.

FIXTURES
Appleton Electric Co.

FIXTURES, CAR LIGHTING
American Metal Products Co.
Crouse-Hinds Co.
Oliver Elec. & Mfg. Co.
Safety Car Heating & Lighting Co.

FIXTURES, GAS AND VAPOR PROOF
Cutter Co., Geo.

FIXTURES, OFFICE, SHOP AND YARD LIGHTING
Central Electric Co.
Hubbell, Inc., Harvey
Westinghouse Elect. & Mfg. Co.

FLASHLIGHTS
National Carbon Co.

FUSES
Federal Electric Co.
Killark Electric Mfg. Co.

FUSES, CARTRIDGE
Appleton Electric Co.
Central Electric Co.
Chicago Fuse Mfg. Co.
Economy Fuse & Mfg. Co.
General Electric Co.

FUSES, ELECTRIC
Federal Electric Co.

FUSES, PLUG
Chicago Fuse Mfg. Co.

FUSES, NON-RENEWABLE
Chicago Fuse Mfg. Co.

FUSES, REFILLABLE
Central Electric Co.
Chicago Fuse Mfg. Co.
Economy Fuse & Mfg. Co.

GENERATORS
Safety Car Heating & Lighting Co.

GENERATORS, AXLE DRIVEN
Safety Car Heating & Lighting Co.

GENERATORS, CAR LIGHTING
Electric Storage Battery Co.
Gould Coupler Co.
Stone Franklin Co.
U. S. Light & Heat Corp.

GENERATORS, HEAD-END
Gould Coupler Co.

GENERATORS, POWER AND LIGHTING
General Electric Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.

GUY ANCHORS
Crouse-Hinds Co.

HANGERS, CATENARY
Ohio Brass Co.

HEADLIGHT REFLECTORS AND CASES
American Metal Products Co.
Crouse-Hinds Co.
Electric Service Supplies Co.
General Electric Co.
Sunbeam Electric Mfg. Co.

HEADLIGHT TURBO GENERATORS
Electric Service Supplies Co.
General Electric Co.
Sunbeam Electric Mfg. Co.

HOSE, AIR, STEAM, ETC.

INCANDESCENT LAMPS
National Lamp Works

INSTRUMENTS, ELECTRICAL
(See Meters)

INSTRUMENTS, (ELECTRICAL MEASURING)
Roller Smith Co.
Weston Electrical Instrument Co.

INSULATING COMPOUNDS
Electric Service Supplies Co.
Standard Underground Cable Co.

INSULATING MATERIALS
Central Electric Co.
Electric Service Supplies Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

INSULATORS
Electric Service Supplies Co.
Ohio Brass Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.

INSULATORS, CATENARY
Ohio Brass Co.

INSULATORS, THIRD RAIL
Electric Service Supplies Co.
Ohio Brass Co.

INTER-COMMUNICATING TELEPHONES
Western Electric Co.

KNIFE SWITCHES
Crouse-Hinds Co.

LABORATORES
Electrical Testing Laboratories

LAMPS
National Lamp Works

LAMP GUARDS
Electric Service Supplies Co.

LAMPS, CAR LIGHTING AND HEADLIGHT
Electric Service Supplies Co.

LAMPS, FLOOD
Central Electric Co.

LANTERNS, ELECTRIC
Federal Electric Co.

LIGHTING UNITS, INDOOR AND OUTDOOR
Central Electric Co.
Hubbell, Inc., Harvey
Westinghouse Elect. & Mfg. Co.

LINE MATERIAL
Central Electric Co.
Electric Service Supplies Co.
General Electric Co.
Ohio Brass Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.

LOCOMOTIVES, ELECTRIC
Westinghouse Electric & Mfg. Co.

LOCOMOTIVES, INDUSTRIAL AND MINE
General Electric Co.
Westinghouse Electric & Mfg. Co.

MAGNETS, LIFTING
Cutler-Hammer Mfg. Co., The

MAZDA LAMPS
National Lamp Works

MECHANICAL RUBBER GOODS

METERS, A. C. AND D. C., PORTABLE
Roller Smith Co.
Westinghouse Electric & Mfg. Co.
Weston Electrical Instrument Co.

METERS, A. C. AND D. C., RECORDING
General Electric Co.
Westinghouse Electric & Mfg. Co.

METERS, A. C. AND D. C., SWITCHBOARD
General Electric Co.
Roller Smith Co.
Weston Electrical Instrument Co.
Westinghouse Electric & Mfg. Co.

METERS, A. C. AND D. C., WATT HOUR
General Electric Co.
Roller Smith Co.
Westinghouse Electric & Mfg. Co.

METERS (CHEMICAL MEASURING)
Weston Electrical Instrument Co.

METERS (ELECTRICAL TESTING)
Roller Smith Co.
Weston Electrical Instrument Co.

METERS (ELECTRIC AMPERE, VOLT AND WATT)
Roller Smith Co.
Weston Electrical Instrument Co.

METERS (ELECTRICAL RECOVERING)
Weston Electrical Instrument Co.

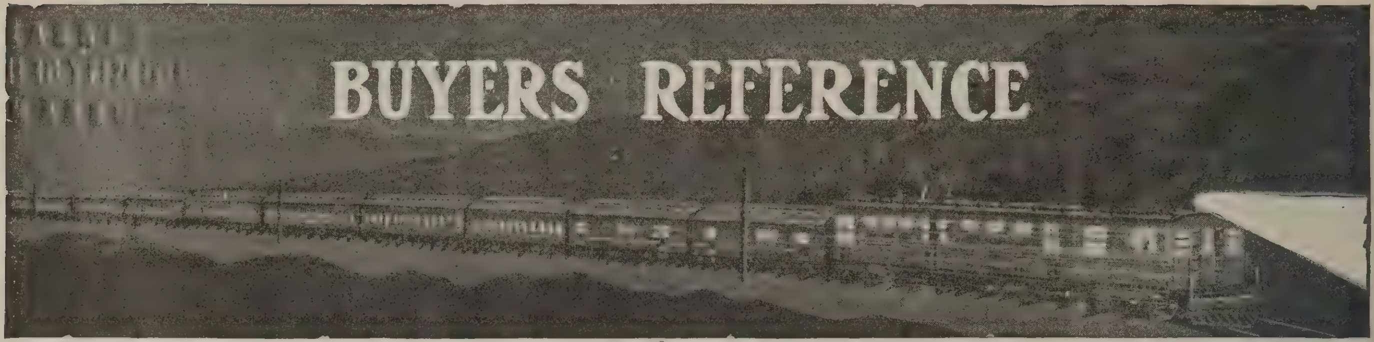
METERS (ELECTRICAL FREQUENCY)
Roller Smith Co.
Weston Electrical Instrument Co.

SUNBEAM
Electric Headlights
and Turbo-Generators

On the L. & N. R. R.

"Sunbeams" in double and headlight service on the L. & N. Sunbeam equipments give long service because they're designed right, built right, and tested right.

SUNBEAM ELECTRIC MANUFACTURING CO.
(Formerly Schroeder Headlight and Generator Co.)
America's Foremost Headlight Builders For 36 Years
EVANSVILLE INDIANA, U. S. A.
NEW YORK RICHMOND, VA. ST. LOUIS CHICAGO SAN FRANCISCO



BUYERS REFERENCE

METERS, POWER FACTOR.
Roller-Smith Co.

MOTOR AND GENERATOR BRUSHES
National Carbon Co.

MOTOR CARS, GAS-ELECTRIC
Fairbanks, Morse & Co.
General Electric Co.

MOTOR STARTERS AND CONTROLLERS
Anderson Co., A. & J. M.
Cutler-Hammer Mfg. Co., The
General Electric Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.

MOTORS, A. C. AND D. C.
Fairbanks, Morse & Co.
General Electric Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.

MULTIPLE UNIT, CARS, ELECTRIC
General Electric Co.
Westinghouse Electric & Mfg. Co.

OHMMETERS
Roller Smith Co.
Weston Electrical Instrument Co.

PANEL BOARDS
Crouse-Hinds Co.
Hart & Heglman Mfg. Co.
Westinghouse Elect. & Mgf. Co.

PHOTOGRAPHIC CARBONS
National Carbon Co.

PLUGS AND RECEPTACLES, ARC WELDING
Anderson Co., A. & J. M.
General Electric Co.
Crouse-Hinds Co.

PLUGS AND RECEPTACLES, BATTERY CHARGING
Anderson Co., A. & J. M.
Central Electric Co.
Crouse-Hinds Co.

PLUGS AND RECEPTACLES, ATTACHMENT
Appleton Electric Co.
Cutler-Hammer Mfg. Co.
Hart & Heglman Mfg. Co.
Hubbell, Inc., Harvey

PLUGS AND RECEPTACLES, POLYPHASE AND MULTIPLE
Central Electric Co.
Crouse-Hinds Co.
Oliver Electric & Mfg. Co.

PLUGS AND RECEPTACLES, POLYPHASE
Central Electric Co.

PROJECTOR CARBONS
National Carbon Co.

PROJECTORS, FLOOD LIGHT
Crouse-Hinds Co.
Electric Service Supplies Co.
Western Electric Co.

REFLECTORS
Central Electric Co.
Electric Service Supplies Co.
Hubbell, Inc., Harvey
Safety Car Heating & Lighting Co.
Westinghouse Elect. & Mgf. Co.

RECEPTACLE BOXES, WEATHER PROOF
American Metal Products Co.

REFLECTORS, CAR LIGHTING
Safety Car Heating & Lighting Co.

REGULATORS, CAR LIGHTING
Electric Storage Battery Co.
Gould Coupler Co.
U. S. Light & Heat Corp.

REGULATORS, GENERATOR
Safety Car Heating & Lighting Co.

REGULATORS, LAMP
Safety Car Heating & Lighting Co.

REPAIR PARTS, AXLE LIGHTING EQUIPMENT
Oliver Electric & Mfg. Co.

REPAIR PARTS, ELECTRIC HEADLIGHT
Oliver Electric & Mfg. Co.

RHEOSTATS, FIELD
Cutler-Hammer Mfg. Co., The
General Electric Co.
Westinghouse Electric Mfg. Co.

RIVET HEATING MACHINE
American Car & Foundry Co.

SELECTIVE APPARATUS FOR TRAIN DISPATCHING
Western Electric Co.

SHADE HOLDERS
Hubbell, Inc., Harvey
Westinghouse Elect. & Mgf. Co.

SHOP AND YARD LIGHTING
Oliver Electric & Mfg. Co.

SOCKETS AND RECEPTACLES, LAMP
Hart & Heglman Mfg. Co.
Cutler-Hammer Mfg. Co., The
Hubbell, Inc., Harvey
Westinghouse Elect. & Mgf. Co.

SOCKETS, LAMPS
Central Electric Co.

SOLDERING COMPOUNDS
Benson Co., Alex. R.

SOLDERING IRONS, ELECTRIC
Cutler-Hammer Mfg. Co., The

STARTING AND LIGHTING BRUSHES
National Carbon Co.

STORAGE BATTERIES
Edison Storage Battery Co.
Electric Storage Battery Co.
Gould Storage Battery Co.
National Carbon Co.
U. S. Light & Heat Corp.

STREET RAILWAYS INCANDESCENT LAMPS
National Lamp Works

SWITCHBOARDS
Anderson Co., A. & J. M.
General Electric Co.
Westinghouse Electric & Mfg. Co.

SWITCH BOXES
Chicago Fuse Mfg. Co.

SWITCHES, AUTOMATIC TIME
Anderson Co., A. & J. M.

SWITCHES, ENCLOSED (SAFETY)
Appleton Electric Co.
Crouse-Hinds Co.
Cutler-Hammer Co.
General Electric Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.

SWITCHES, END CELL
Anderson Co., A. & J. M.

SWITCHES, FROG, ETC.
Appleton Electric Co.

SWITCHES, HEADLIGHT
Electric Service Supplies Co.

SWITCHES, KNIFE
Anderson Co., A. & J. M.
Appleton Electric Co.
General Electric Co.
Hart & Heglman Mfg. Co.
Westinghouse Electric & Mfg. Co.

SWITCHES, SNAP, PUSH AND PENDANT
Cutler-Hammer Mfg. Co., The
Hart & Heglman Mfg. Co.

SYNCHROSCOPES
Roller Smith Co.
Weston Electrical Instrument Co.

TELEPHONE APPARATUS
Western Electric Co.

TRANSFORMERS, INSTRUMENT
General Electric Co.
Roller Smith Co.
Westinghouse Electric & Mfg. Co.
Weston Electrical Instrument Co.

TRANSFORMERS, POWER AND LIGHTING
Electric Service Supplies Co.
General Electric Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.

VOLT METERS
Roller Smith Co.
Weston Electrical Instrument Co.

WATT METERS
Roller Smith Co.
Weston Electrical Instrument Co.

WELDING CARBONS
National Carbon Co.

WELDING WIRES
Reid-Avery Co.

WIRE, BARE
Anaconda Copper Mining Co.
Copper Clad Steel Co.
Standard Underground Cable Co.
Western Electric Co.

WIRE, CONNECTING
Appleton Electric Co.

WIRE, COPPER CLAD STEEL
Copper Clad Steel Co.
Standard Underground Cable Co.

WIRE, INSULATED
Copper Clad Steel Co.
Central Electric Co.
General Electric Co.
Habirshaw Electric Cable Co., Inc.
Hazard Mfg. Co.
Kerite Insulated Wire & Cable Co.
Okonite Co.
Standard Underground Cable Co.
Western Electric Co.

WIRE, LOCOMOTIVE HEADLIGHT
Habirshaw Electric Cable Co., Inc.

WIRE, TELEPHONE AND TELEGRAPH
Copper Clad Steel Co.
Hazard Mfg. Co.
Kerite Insulated Wire & Cable Co.
Standard Underground Cable Co.
Western Electric Co.

WIRE, TROLLEY
Copper Clad Steel Co.
Standard Underground Cable Co.

ALPHABETICAL INDEX

Adapti Co., The 20
American Car and Fdy. Co 19
American Metal Products Co 27
Anderson Mfg. Co., Albert & J. M 40
Appleton Electric Co 40

Benson Co., Alex. R 44
Bryant Electric Co., The 26
Buyers' Reference 46, 48

Central Electric Co 8, 9
Chicago Fuse Mfg. Co 23
Copper-Clad Steel Co 45
Crouse-Hinds Company 35
Cutler-Hammer Mfg. Co., The 4

Dodge Sales & Engineering Co 43
Economy Fuse & Mfg. Co 34
Edison Storage Battery Co 6, 7
Electric Arc Cutting and Welding Co 45
Electric Service Supplies Co 41
Electric Storage Battery Co., The 12
Electrical Equipment & Machinery Co —
Electrical Testing Laboratories 44

Fafnir Bearing Co., The 2
Fairbanks, Morse & Co 38
Federal Electric Co 24
Flexible Woven Cable Co 25

General Electric Co 30, 31
Goodrich Rubber Co., The B. F —
Gould Storage Battery Co 3

Habirshaw Electric Cable Co., Inc 21
Hart & Hegeman Co 22
Hazard Mfg. Co 29
Hubbell, Inc., Harvey 28

Ideal Commutator Dresser Co 43

Kerite Insulated Wire & Cable Co 37

National Carbon Co., Inc 15
National Metal Molding Co 17

Ohio Brass Co., The 41
Okonite Co 1
Oliver Electric & Mfg. Co 18

Pyle-National Co 33
Roller-Smith Co 42

Safety Car Heating & Lighting Co., The 13
S K F Industries, Inc 32
Standard Underground Cable Co 44
Stone Franklin Co 14
Sunbeam Electric Mfg. Co 47
U. S. Light & Heat Corp 50
War Department 10, 11
Western Electric Co 39
Westinghouse Electric & Mfg. Co 16, 49
Weston Electrical Instrument Co 45
Willard Storage Battery Co 5

For Railway Service

POOR lighting is not alone a strain on the eyes of workers, but the lack of good lighting for shops, yards and station platforms is a burden carried at the expense of reduced output, in short a strain on operating expense.

CUTTER REFLECTORS

designed according to the latest and best illuminating practice, give types of light distribution which exhaustive tests and extensive use have proved best suited for railway service.

Cutter Reflectors and Holder Sockets,

in fact have proved their value in terms of better illumination and decided savings both in time and money.

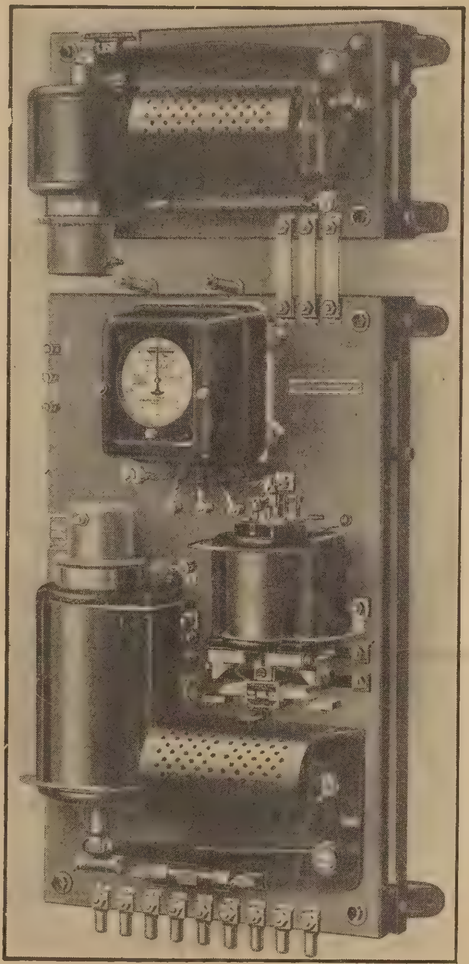
Correct design increases maximum *useful* light. Practical construction helps save installation cost, and to cut cleaning expense to a minimum, in short *Cutter Industrial Lighting Equipment cuts lighting costs.*

Write and have us show you how Cutter Reflectors afford saving which is reflected in your cost sheets.

Westinghouse Electric & Manufacturing Co.
George Cutter Works
South Bend, Indiana

Westinghouse

OPERATING COSTS REDUCED WITH USL AMPERE HOUR CONTROLLED CAR-LIGHTING SYSTEM



Type C Ampere-Hour-Control Panel With Type B Lamp Regulator

A prominent Chief Electrician states that "Aside from the value of the meter as a means for controlling the amount of charge to a battery, it has another use to which many attach considerable importance, and that is to indicate the state of charge of the battery. An electrician inspecting the equipment upon arrival takes note of the meter readings and is able to judge whether the equipment has been working properly on the trip just finished; also, without going to further trouble he can form an opinion as to whether the battery has sufficient charge in it to insure proper lighting of the car up to the time the axle generator becomes operative.

Our yard electricians, as well as inspectors and supervisors, insist that the meters furnish information which is too valuable to be without."

The Ampere Hour Meter keeps the battery healthy and increases its life. With it the battery works only 20% and floats 80% of the time.

Less battery work means less cleaning and flushing, fewer replacements and less depreciation, all of which aid in lowering operating costs.

U. S. LIGHT & HEAT CORPORATION
Factory: Niagara Falls, N. Y.
Branches: New York Chicago Detroit Kansas City San Francisco Washington, D. C.

USL
U. S. LIGHT & HEAT CORPORATION
Car-lighting Equipment

UNIVERSITY OF ILLINOIS-URBANA
3 0112 066918795